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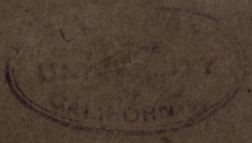

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THE

MOSAICAL AND MINERAL GEOLOGIES,

&c.

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MOSAICAL AND MINERAL GEOLOGIES,

ILLUSTRATED AND COMPARED.

BY

W. M. HIGGINS, F.G.S., &c.

LONDON:

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THE

MOSAICAL AND MINERAL GEOLOGIES,

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INTRODUCTORY REMARKS.

As the sciences have advanced towards perfection, they have not only tended to illustrate the sacred record, but have afforded new arguments in favor of its authenticity. Yet there have always, in the infancy of science, been found individuals who, after an imperfect examination of nature, have formed such deductions as have led them to deny the inspired character of the Bible; while others, professing to receive that book as of divine authority, have doubted the propriety of comparing it with the discoveries of philosophy. The one class has boldly impugned its claims as a revelation from God; the other has virtually denied the truth of its statements,

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by rejecting its philosophy, and withdrawing it from investigation.

It is a matter of importance to those who are convinced of the authenticity of the Bible, that its philosophy should be properly understood, investigated in its details, and compared with nature: and should the examination conducted by them be at first unsatisfactory, and the harmony of God's word and works unapparent, the combination of irresistible arguments, which had convinced them of the truth of revelation, will lead them to conclude that there are imperfections in their knowledge, or error in their deductions.

The man who has been unconvinced of the divine character of the Bible, by the arguments which are so powerful to Christians, will compare Geology and the Mosaical History of the Creation with different feelings. Should he be unable to reconcile the statements of the two, he will not hesitate to prefer his own deductions to the clearest assertions of the Scriptures, and perhaps adduce it as a fresh argument against its authenticity.

It would be well for such a mind to remember, that Geology is as yet only in its cradle, and its nurses have scarcely recognised the features of its countenance. Many of those facts which are now received as principles, may hereafter be found to be exceptions, and

thus overturn all those deductions which are built upon them: and as so many theories, proposed by men of acknowledged genius, have been disproved by the accumulation of knowledge, so it is possible that those upon which he is placing so much reliance, may hereafter share the fate of their predecessors.

But there are some persons, who, though they admit the inspired character of the Bible, doubt the propriety of attempting to draw a parallel between the scriptural representations of the creation, and the discoveries of Geologists, supposing that it is unreasonable to expect physical truths in a record intended for moral and spiritual purposes. We are not a little surprised to find Professor Sedgwick, a gentleman of great argumentative talent, and a most successful Geologist, maintaining these opinions. "Laws for the government of intellectual beings," says the Professor, "and laws by which material things are held together, have not one common element to connect them: and to seek for an exposition of the phenomena of the natural world among the moral destinies of mankind, would be as unwise as to look for rules of moral government among the laws of chemical combination." *(Geol. Society's Proceedings,* p. 207.)

The question is not whether we ought to expect a

statement of physical truths in a work intended to promote the spiritual welfare of mankind, but whether those statements relative to the creation of the world, which are given in the Bible, do coincide with those facts which are discovered by an examination of the constitution of the globe itself. Those who believe the scriptures to be a divine revelation, cannot suppose that the inspired historian was permitted to teach falsehood when he sketched the outlines of the history of creation. Yet the statement is either true or false; and, if it does not accord with the facts of Geology, it is the duty of every honest mind to examine into the cause of the contradiction, and to determine for itself whether Genesis or Geology be more worthy belief.

In this view of the subject we are supported by the authority of Mr. Watson, the able author of "Theological Institutes." "It has been replied," says this divine, "that the Bible not being intended to teach philosophy, it is not fair to try it by a philosophical standard; this, however, cannot be maintained in the case before us, though the observation may be pertinent in others. If Moses professes, by divine inspiration, to give an account of the manner in which the world was formed, he must describe the facts as they occurred." (*Theol. Inst.*, vol. i. p. 273.)

To deny the propriety of examining the Mosaical History, for the purpose of comparing it with science, is to insinuate its falsehood. Those Geologists who have formed or adopted theories of the earth, have done so from a belief of their truth: and professing themselves the friends of revelation, they could not hesitate to compare them with this standard of their faith, did they not believe them inconsistent with its statements. But the question must be fairly met and argued. Thinking men are not so easily satisfied as to receive opinion for argument, assertion for proof; and should their doubts reach those who have not the disposition to investigate for themselves, they cannot fail to have an injurious effect upon their minds.

But this is not the extent of the evil. Admit that one portion of the Mosaical writings is uninspired, and a doubt of the authenticity of the remainder is also insinuated. Happily, however, the whole system of revealed truth stands on too sure a foundation to be shaken. The Bible, as a literary composition, as a system of morality and theology, and as a revelation from the universal Creator, demands the first and closest consideration of man: on every subject to which it refers it is infallible, and to its decision human reason must submissively bow.

With these sentiments we commenced a comparison of the Mosaical History of Creation and the principles of Geology. If we had been unable to trace the harmony of the two, we could not on that ground have doubted the Mosaical description, for it is substantiated by more numerous and powerful arguments than can be adduced in favor of Geological opinions. We could only, under such circumstances, have waited for a further development of Geological facts. Should the comparison we have drawn in the following pages fail to convince the sceptical reader, it is hoped that he will see the propriety of the same course; and the author is certain that the Christian who may differ from him in the interpretation of the Sacred History, will treat his opinions with the same candour which he himself expects from others.

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OUTLINE OF PRACTICAL GEOLOGY.

THE economical importance of Geology may be said to consist in the knowledge it affords us of the repositories of the metallic ores and coal. Before the researches of Geologists had determined the regular succession of rocks, the discovery of these must have depended either on a fortunate trace of their presence, or their actual appearance at the surface. But we are not now left to such miserable chances; their associated rocks are known, their situations determined, and to their favorable position and abundance in our island we are greatly indebted for that high commercial station we hold in the scale of nations.

But the proper object of Geology is to discover the circumstances under which the beds composing the crust of our globe, were formed. With this view we examine the mineralogical characters of rocks, and compare them with those that are still formed by rivers and seas, or by volcanos and mineral springs; and while we gain much information concerning the causes

by which a bed was formed, from the mere examination of the structure, we are able, by the study of the organic remains it contains, to form some adequate notion of the circumstances under which they lived, and consequently the condition under which the bed itself was formed.

The most careless observer of nature must know that the earth is not a solid mass of an individual substance. It is hardly possible to pass over the most limited district, and not discover this fact; sand and sandstone, clay and limestone, are universally found in all parts of the world.

From a partial examination of these various deposits, we might be led to suppose that they were indiscriminately situated in relation to each other. This opinion is still held by nearly all those persons who have not paid some attention to Geology. The interior of that world which exhibits such wonderful order and skilful arrangement on the surface, is in their imagination a very sample of confusion. So natural is this supposition, that it is probable we might still have indulged the error, had not the investigations of miners insensibly led them to trace the super-position of rocks. It was early discovered by these practical Geologists, that certain ores were always found in certain rocks,

and that certain other rocks accompanied those in which the ores appeared. In their search for ores, therefore, they endeavoured to assure themselves of the presence of some of these beds, before they expended either capital or labour in closer examination. The more scientific observations which have since been made, have extended the facts which they observed in particular instances to the whole system of mineral masses; and there is now no principle better substantiated than the regular superposition of rocks.

But it is quite possible to take this statement in too general a manner. It must not be supposed that our earth is composed of a series of concentric beds, like the coats of an onion, so equably spread over each other that it is only necessary to pass through them in one place to know the constitution of the whole globe.

The crust of the earth, and it is only the crust that is open to investigation, is composed of so many beds, that Geologists have been compelled to class them in orders, formations, and sub-formations. A series of beds which appear to have been formed by nearly the same cause, and operated upon subsequently by the same agents, are united by Geologists, and called a sub-formation. Several of these sub-formations, when united together, make a formation, and a union of

formations an order. Now a sub-formation may in one place contain more beds than in another, or it may be different in mineralogical characters.

We may illustrate this subject by reference to a locality. Let us suppose that four series of rocks, called the chalk, upper green sand, gault, and lower green sand formations, are found resting upon each other.

The upper portion (chalk) of this series presents the same characters in nearly all parts of the world. But although this may be considered as the most uniform of all the formations, yet there are certain local variations in its mineralogical characters. It is generally soft, and of a white colour; but between Havre and Rouen it is so indurated, as to take the appearance of a compact limestone; and it is well known that in some parts of the north of England, it has a red colour.

Beneath the chalk we come upon a series of beds called the upper green sand. The beds of this formation are very different in certain localities, yet it is generally observed that the upper beds are cretaceous, and that the lower have a sandy character.

Gault, which comes next in position, chiefly consists of a blueish gray clay and marl; but this formation also varies in different places.

The lowest formation of this series is that called the lower green sand. This consists of sands and sandstones, of various colours and degrees of induration: but its prevailing colour is green.

A rock which is usually found in a certain position, may in particular localities be entirely wanting, or be found in so different a character as to be scarcely recognized. In one situation we may observe a series of rocks to consist of a great variety of beds, very different in their mineralogical appearance; but, in another place, the same situation in the general succession of rocks may be occupied by but few beds, and these greatly resembling each other in appearance and constitution.

Rocks may be divided into two natural classes, the stratified and unstratified; the greater part are stratified, and at an angle more or less inclined to the horizon. On this account the edges of the beds emerge in succession from beneath each other, and make their appearance at the surface of the earth.

Had rocks occurred in a perfectly horizontal position, the same rock would have spread over a considerable tract of country; and it would then have been difficult to have obtained many of those minerals which are now found at the surface of the earth. But in the arrange-

ment that has been adopted, we cannot but acknowledge the superintending wisdom and power of God, ordaining those causes which should produce a world best fitted to promote the happiness, and support the social character, of his future creature, man.

The mineral masses are for the most part stratified, and the stratification is generally more or less inclined to the plane of the horizon; but this is not the universal position of stratified beds. Not unfrequently they take a basin shape, as may be seen in many of the coal districts, and in the secondary rocks. Paris and London stand on these basin-shaped beds, and the same stratification is beautifully developed in the Isle of Wight. Rocks also present what is called, from its branching appearance, a fan-shaped stratification, and at other times a saddle shape, which is the reverse of the former, or may be compared to the section of a roof. These three kinds of stratification are so variously modified, that it requires some extent of observation, before the great violence and varied action of those subterranean forces which have been chiefly instrumental in giving them their forms, can be fully estimated.

The natural position of the unstratified rocks is below all others, but they sometimes intrude themselves among

those which, in an undisturbed position, lie above them. We therefore find them in nearly all parts of the series, sometimes intersecting rocks in the form of veins, and at other times super-posing them, as though they had flown over them in a manner similar to the lavas of the present day. And not unfrequently they have been instrumental in forming mountains of very considerable elevation, from the influence they have exerted upon rocks, tilting the horizontal strata in some instances, and in others so disrupting them as to expose them to the influence of denuding waters.

The unstratified rocks, therefore, cannot be said to occupy any determinate situation in the geological series. Sometimes they are found in connexion with the non-fossiliferous group, which is the lowest series of rocks; and at other times, with the mammiferous group, which is the highest, and with all the intermediate series. Instances of this may be easily adduced: at Klostergrab, in Bohemia, some rocks of the granitic group are associated with the non-fossiliferous, stratified; in Norway, with the lowest fossiliferous; in Saxony, with the grauwacke; in Germany, with the red sandstone group; and at Angers, with the mammiferous.

Another classification which rocks admit, is into Fossiliferous and Non-fossiliferous. The lower beds of

that portion of the earth's crust with which we are acquainted are destitute of all remains of organized beings, and are usually called the Primitive or Primary Rocks, as they are supposed to have been formed before the creation of things that have life. The unstratified rocks are also destitute of fossils, as we might expect, for they are almost unanimously attributed to the action of fire. But, excepting the few stratified beds called Primitive, and the unstratified, nearly all others contain organic remains, some of which are of a most remarkable character, and now extinct.

It has also been discovered that every fossiliferous formation contains certain organic remains peculiar to itself, wherever it may be found. It has already been stated that the same formation varies considerably in its mineralogical characters, and geologists have consequently been compelled to identify beds by their fossils. London and its vicinity stands on a clay which is called the London or blue clay. In the neighbourhood of Paris, a coarse sandstone, the calcaire grossiere, occupies the same position in the series as the blue clay in London. The mineralogical characters, in this instance, are of little value in determining the identity of the strata. The value of fossils, therefore, is immense; it enables us at once to decide upon the

relative position of a bed, whatever may be its local situation; and to recognise it as well from a few of its organic remains, as though we had examined the country in which it occurs. It has, therefore, become an object of great importance to Geology that the fossils of every bed should be collected. Naturalists have been induced to extend their investigations into the bowels of the earth, a new world has been opened to inquiry; a race of beings, before entirely unknown, have been discovered, and a datum established by which every geological problem may be solved.

The wonder of thinking men has ever been excited by the discovery of the remains of organized bodies in the solid strata of the globe. That these have been objects of curiosity and investigation from the earliest ages of civilization is not to be doubted; at any rate, speculations on their nature, and the causes which produced them, were indulged long before the science of geology possessed a name. Some of these have reached us, and appear remarkably ridiculous, and little to be preferred to the notions of the most ignorant peasant of our own day; but since it has been discovered that every bed has its particular fossils, oryctology has risen into great estimation. This interesting truth was first observed by Lister, upwards of one hun-

dred and fifty years ago; but the honour of demonstrating it by extensive observations is due to Mr. Smith.

The first classification of rocks was formed upon the presence or absence of organic remains; for the lower rocks being destitute of them, were supposed to have existed before the creation of things which had life, and were hence called the Primitive or Primary Class, and those which possessed them, the Secondary. But as the science advanced, the importance of an intermediary class, to comprise those beds which are formed of conglutinated fragments of primary rocks, appeared evident, and was adopted, under the name of the Transition, or Fragmentary class. Another division, called the Tertiary, or Upper Secondary, has been since added; so that, according to this system, the substances which form the crust of our globe, may be arranged in four classes:

1. The Primary, or Crystalline.
2. The Transition, or Fragmentary.
3. The Secondary, or Sedimentary.
4. The Tertiary, or Upper Secondary.

It was long a disputed point with Geologists, whether rocks should be arranged according to a mineralogical

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or geological classification; those who maintained the propriety of a mineralogical arrangement, urged its advantages as a natural system, because it separates between simple and compound rocks, avoids the repetition which is necessarily connected with any other method, introduces a perfect nomenclature, and involves no hypothetical opinions. But with all these pretended advantages, what would geology be with such an arrangement, but a mass of uninteresting, not to say unintelligible, facts? It disjoins that which nature has united, it affords no clue to the relative ages of rocks, involves, it is true, no hypotheses, but at the same time banishes all our facts: in truth, it at once saps the foundation of that beautiful fabric of knowledge, in the construction of which the geologist has been so laboriously employed.

No system can be of any value to the student that is not formed on geological principles. It is admitted that a perfect arrangement upon this plan cannot as yet be attained, for geologists have not yet sufficient knowledge to enable them to accomplish their desire. But as far as we are interested in the pursuit of this desirable object, we are convinced that it is only by maintaining in our classification that arrangement observed in nature, that real knowledge can be imparted to others. But, notwithstanding the disadvantages

connected with the classification of rocks, our knowledge has so increased, as to enable us to improve that arrangement which was formerly adopted; yet such is our natural prejudice for those things to which we have been accustomed, that geologists have not sufficiently availed themselves of their increased information.

The Wernerian classification, which we have illustrated in the preceding table and remarks, was universally used in this country till the publication of "Connybeare's Geology of England and Wales." In this work a new classification was adopted, and the crust of the earth divided into five portions, forming the following classes:

1. The Superior, containing the tertiary deposits.
2. The Supermedial, containing the chalk, green sand, wealden, oolitic, and red sandstone formations.
3. The Medial, containing the coal-measures, carboniferous limestone, millstone grit, and old red sandstone formations.
4. The Submedial, comprising the transition rocks.
5. The Inferior, containing the primitives.

The most convenient and useful classification that has been yet introduced, we think, is that proposed some time since by Mr. De la Beche in the Annals of Phi-

losophy, and since adopted with great success in his "Manual of Geology." But there are many objections to new classifications, which prevent Geologists from adopting those suggestions which they may consider improvements. By using an established classification, the scientific of all countries are able to correspond with each other; but if a new arrangement be adopted, it must necessarily be a considerable time before it can be understood, and prejudice would prevent, in many instances, its adoption. Such alterations can only be effectually introduced by societies: for even old nomenclature will be preferred to modern improvements, as we see in the alterations proposed by Mr. Conybeare; for although his classes are far less objectionable than the Wernerian, they have never been generally adopted. It would, therefore, perhaps be desirable that the Geological Society should give some attention to the subject; but for the present use of the Geologist, we decidedly recommend the classification proposed by Mr. De la Beche.

All rocks may be divided into stratified and unstratified; we have, therefore, in this fact, two leading divisions not formed in the study, but from nature. Some objection may be made to the arrangement, under a supposition that it will impede our knowledge of the

superposition of rocks; but the separation of stratified and unstratified beds is of no consequence, for the latter are found in connexion with strata of all characters and in all situations. The next general truth is, that the lower stratified beds do not contain fossils, whereas the others do; hence we have a subdivision into fossiliferous and non-fossiliferous. It then only remains to arrange the strata into groups and formations, and we at once obtain an easy and natural system of rocks. The following pages will be arranged according to this plan, of which the reader will obtain an accurate notion by the following table:

STRATIFIED ROCKS.

Groups.	
1. Alluvian.	Peat bogs, sands, coral islands, &c.
2. Diluvian.	Transported boulders and blocks, gravel, &c.
3. Supercretaceous.	Upper and lower freshwater, and marine formations.
4. Cretaceous.	Chalk, green sand, and wealden rocks.
5. Oolitic.	Oolites and lias.

Groups.	
6. Red sandstone.	Red marle and sandstone, magnesian limestone, and red conglomerate.
7. Carboniferous.	Coal measures, carboniferous limestone, and old red sandstone.
8. Grauwacke.	Grauwacke and grauwacke slates.
9. Lowest fossiliferous.	Argillaceous and other slates.
10. Non-fossiliferous stratified.	Mica slate, gneiss, &c.

UNSTRATIFIED ROCKS.

Groups.	
1. Volcanic.	Lavas, &c.
2. Trappean.	Greenstone, basalt, porphyry, amygdaloid, &c.
3. Serpentine.	Diallage rock and serpentine.
4. Granitic.	Syenite, granite, &c.

Having taken this general view of the elementary principles of Geology and the classification of rocks, it only remains for us to give some account of rocks themselves. The following Table of all the stratified beds is arranged according to Mr. De la Beche's system.

Group.	*Formation*	*Sub-formation.*	*General Character.*	*General and characteristic Fossils*
ALLUVIUM.			Gravels, clay, and sand, formed by existing causes.	Plants, shells, and animals, still existing.
DILUVIUM.			Gravels, clays, and sands, immediately superposing the ancient beds.	Bones of animals, terrestrial and marine. Rhinoceras trichorhinus.
SUPERCRETACEOUS.	Upper fresh water formation.		Beds variable, chiefly marls and millstones.	Fresh water shells and terrestrial plants.
	Upper marine.		Sandstones, sands, and greenish marl.	Marine shells; fresh water, and terrestrial shells, and plants subordinate.
	Second fresh water formation.		Marl, gypsum beds, and limestones.	Terrestrial and fresh water plants, shells, birds, saurians and carnivora.
	Second marine formation.	London clay, or calcaire grossier.	In Paris, course limestones and marls. In England, blue clay.	Marine plants, shells, and turtles; terrestrial plants, subordinate. Cerithium gigantium.
		Plastic clay.	Sands and clays.	Lignite, terrestrial. Fresh water, and marine shells.
CRETACEOUS	Chalk formation.	Upper chalk, Lower chalk.	The upper portion is generally soft, and contains flint; the lower is hard, and without flints.	Plants, Alcyonia, shells and fish. Marine. Inoceramus Cuvieri.
		Upper green sand.	Sandstones and marl.	Alcyonia, shells, and fish. Ostrea carinata.
	Green sand formation.	Gault.	Marly clay.	Plants, shark's teeth, and testacea. Inoceramus sulcatus.
		Lower Greensand.	Ferruginous and green sands.	Plants, corals, shells, fish, &c. Trigonia aliformis.

Group.	*Formation*	*Sub-formation.*	*General Character.*	*General and characteristic Fossils*
CRETACEOUS *(Continued)*	Wealden formation.	Weald clay.	Dark blue clay, and clay ironstone.	Shells, fish, and crocodiles. Fresh water.
		Hastings sands.	Sand and sandstones.	Plants, shells, fish, reptiles, and birds.
		Purbeck beds.	Limestones and marl.	Ostrea, fish, and crocodiles. Fresh water and marine.
OOLITIC	Portland Oolite.		Limestones.	Wood, corals, shells, & fish. Marine. Ammonites triplicata.
	Kimmeridge clay.		Blueish clay and bituminous shale.	Testacea and reptiles. Marine. Ostrea deltoida.
	Coral rag.		Sandstone, limestones, and sands.	Wood, corals, and shells. Marine.
	Oxford clay.		Dark blue clay and limestones.	Wood, testacea, and reptiles. Gryphæa dilata.
	Cornbrash.		Rubbly limestone and clay.	Testacea and reptiles.
	Forest marble.		Limestones and sands.	Plants, testacea, elytra of insects, birds, and reptiles.
	Bradford clay.		Marly clay.	Corals and marine shells. Apiocrinites rotundus.
	Great oolite.		Oolitic limestones.	Plants, corals, and shells. Marine.
	Fuller's earth.		Clay and Fuller's earth.	Marine testacea.
	Inferior oolite.		Limestones and calcareous sands.	Marine shells and crustacea; some terrestrial plants.
	Lias.		Blue marl and limestones.	Plants, shells, fish, & reptiles. Marine. Gryphæa incurva.

Group.	*Formation*	*Sub-formation.*	*General Character.*	*General and characteristic Fossils*
RED SANDSTONE.	Red marl.		Variegated marls, containing gypsum.	Terrestrial plants.
	Muschelkalk		Limestones.	Marine plants and testacea.
	New red sandstone.		Micaceous sandstones.	Terrestrial and marine plants, and a few testacea.
	Magnesian limestone.		Magnesian limestones, and marl containing gypsum and rock-salt.	Marine fish and testacea.
	Red conglomerate.		Sandstones and conglomerates.	No fossils.
CARBONIFEROUS.	Coal measures.		A series of coal, sandstone, and shale beds, irregularly alternating.	Terrestrial and fresh water plants and shells.
	Millstone grit and shale.		Quartzose sandstones and shales.	Terrestrial plants.
	Carboniferous limestone.		Blueish limestone.	Plants, encrinites, corals, shells, vertebræ and teeth of fish. Marine.
	Old red sandstone.		Dark brown siliceous sandstone.	Terrestrial plants, but rare.
GRAUWACKE	Grauwacke.		Arenaceous and slaty beds, containing limestones.	Marine plants, shells, and crustacea.
LOWEST FOSSILIFEROUS.	Slate.		Clay and other slates.	Shells.
NON-FOSSILIFEROUS STRATIFIED.	Chlorite, Talcose, and Hornblende, slates, Limestone, Gneiss, &c.		Schistose rocks and crystalline compounds.	

This table will, we hope, convey, in as few words as possible, the general superposition of the stratified rocks, and their classification. It may not, however, be altogether unacceptable to the general reader if we indulge in a few remarks upon the several groups. To enter at large upon a description of the formations, would be to write a Treatise upon Geology. Our observations, therefore, must be brief and imperfect, being only intended to give an outline of the principal phenomena, and to draw the attention to some more detailed statements.

The Alluvian Group consists of all those rocks which are now forming; such as the depositions from rivers and springs, lavas, coral reefs, and submarine forests.

In various parts of this and other countries, large accumulations of wood and plants, resembling in species those which now exist, have been found. They all appear to occur at a level beneath high-water mark, and are generally upon the shores of the sea, or in its estuaries.

We recently observed a submarine forest in the estuary of Maldon, Essex, which consists of terrestrial plants. In the deposit may be found the birch and the hazel,

the latter having its nuts quite perfect, though destitute of kernels. There is another in the estuary of Salcombe, Devon; but the wood is too decayed and compressed to admit of distinguishing the trees of which it is composed.

Peat is a substance certainly derived from decayed vegetable mingled with earthy matter, and has taken its present form from the chemical action of humidity and pressure, producing a partial carbonization and bituminization. It has been found, by the examination of the peat bogs of England and Ireland, that they principally derive their origin from a species of moss which grows in damp situations, and to the casual inclusion of timber and smaller trees. In many places the peat is found to be of considerable thickness, and must have been the product of many ages. The manner in which it is accumulated is well known: the moss of one year's growth is covered by that of the following, until a mass of considerable thickness is accumulated. The air being excluded, and the pressure being increasingly great, the lower portions, after partial decomposition, become solidified, and in process of time parts with its organic structure, becomes carbonised or bituminized, and in some instances passes into a substance precisely similar in

chemical composition to jet. Its general properties are a brown or black colour, and bituminous character. It is said to produce more ashes than any other combustible substance, and contains sulphate of potash and alumina in greater or less abundance.

There are several varieties of peat, and three are recognised in commerce; the light, the medium, and the hard peat. These several sorts are occasioned by local causes, such as the following:

1. The character of the vegetable substance composing it.
2. The quantity of water infused into the bed, and its state of decay.
3. The thickness of the deposit.
4. The weight of the other alluvian substances that superpose it.

Peat beds are usually found in the bottom of ancient lakes, or of those which are still covered by water. They are also sometimes observed in high table lands, and other places, but we believe that they never occur except in humid situations. Peat beds frequently contain the trunks and branches of trees, animal bodies, coins, and workmen's tools, and are of more recent formation than submarine forests.

Of the other alluvian deposits it is not necessary to speak, as we shall have occasion to refer to them in another place.

THE DILUVIAN GROUP includes the superficial gravels, erratic blocks, and other deposits, attributable to a great Diluvian action that occurred after the deposition of the supercretaceous beds.

It is quite certain that pebbles can only be formed by the action of water. If we examine the stones which lie upon the shores of the sea, or the margin of lakes, we universally find them smoothed by the action of waves; and we can have no better proof of the former existence of a water-course, than the presence of rolled pebbles. Now, the whole earth is covered with this proof of its having suffered under a universal deluge. By the force of conflicting waters, rocks have been broken and disintegrated; those which have been of such a chemical composition as could resist water, have been rolled by it, and those which could not resist the solvent principle, have been united with the water and afterwards deposited on the rolled pebbles, forming those beds of gravel which now cover the surface of our planet.

The fossils which are found in Diluvium are varied

and numerous. As all rocks have suffered under the effects of this deluge, so the fossils of all rocks may be found; but in addition to these we find many bones of the mammalia, which have not been discovered elsewhere. Among others which have been recognized in these deposits, we may mention those of the elephant, mastodon, hippopotamus, rhinoceros, hyæna, bear, and a very large elk. Several of the species of these animals whose bones we find are now quite extinct.

At the same or nearly the same period that these beds of gravel were formed, a great number of caverns were excavated, and in these a vast accumulation of bones have been found. For our intimate acquaintance with these, we are chiefly indebted to the investigations of Dr. Buckland, at Kirkdale. Kirkdale is situated about twenty-five miles from York, between Helmsley and Kirby Moorside. The position of the cave is at the lower extremity of the dale of the Hodge Beck. Its greatest length is about 245 feet, but there are only two or three places where it is possible to stand upright. The bottom of the cave, on first removing the mud, was found to be strewed from one end to the other with hundreds of teeth and bones, or rather broken and splintered fragments of bones, belonging to twenty-three different species of animals. Dr.

Buckland supposes this cave to have been, during a long succession of years, inhabited by hyenas, and that they dragged into its recesses the other animal bodies whose remains are found mixed indiscriminately with them. All the bones appear as though they had been gnawed, and there are evidences of not less than two or three hundred hyenas.

The Supercretaceous Group. Previous to the investigations of MM. Cuvier and Brogniart, in the neighbourhood of Paris, the beds which are comprized in this series were supposed to be mere superficial gravels, clays, and sands, of the same age as the Diluvian group. But by their labours and the investigations which have since been carried on in various parts of the globe, it has been discovered that they have a considerable geological importance. A great variety of terrestrial, freshwater, and marine remains, some belonging to genera now unknown, and others analogous to recent specimens, have been discovered in the various strata which compose the series.

About the same time that the French Geologists were investigating the Supercretaceous group in the neighbourhood of Paris, Mr. W. Smith, who will ever stand high in the estimation of Geologists, was engaged in

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tracing the superposition of English rocks; during which investigation, he discovered the fact to which we have already referred, that every series of beds contains organic remains which are peculiar to itself.

To determine the succession of the Supercretaceous rocks, we must necessarily depend upon this all important principle, and arrange the beds by their fossils. Either from the locality of the causes which produced these rocks, or from the disturbances which they have since suffered, we are not yet informed of any situation in which all the deposits already known are collectively found. In various parts of the globe we find small individual collections of these beds, but it is a matter of considerable difficulty to identify them with those which are found in other situations. Our only resource, therefore, in endeavouring to decide the relative ages, or, in other words, the succession of many of the beds belonging to the Supercretaceous group, is by their fossils.

We cannot, however, but express a doubt which we have long felt, relative to the age of several of the beds which are classed in this group. May not many of the isolated deposits which are now arranged in this series, belong to the Diluvian period? Nothing can be more certain than that the world has suffered under an over-

whelming flood; to its action we attribute that bed of detritus which is found in every investigated country, superposing formations of every age, indiscriminately as they appear at the surface. But it does not seem probable that this should be the only effect of that revolution. In some places it must have been more violent than in others, and its activity more continued; and we may reasonably expect that future investigations will prove that many of the detached beds which are now classed with this group, will be found to belong to the Diluvian series.

M. Beaumont has discovered a most interesting, and probably one of the most recent, deposits of the Supercretaceous group in the valleys of the Isére, and Rhone. It consists of a series of pebbles and sand; and all the former may be traced to the Alps. It is several hundred yards thick, and contains beds of lignite, in which are found the freshwater shell called Planorbes. M. Beaumont supposes it to have been formed in the waters of a shallow lake, which existed subsequent to the upheaving of the Alps of Savoy and Dauphiny, but previous to the elevation of the main chain from the Vallais, in Austria; and that the pebbles and sand were transported by the action of torrents from the Alps to the situation where they are now found.

The Crag, which occurs so abundantly in Norfolk and Suffolk, is another of the Supercretaceous rocks. This deposit varies considerably in its mineralogical characters; it is composed of a series of sand and gravel beds, and other mechanical rocks, some of them being remarkable for the marine productions they contain. The beds of this formation have been arranged by our friend Mr. R. C. Taylor, in an unpublished paper, into two natural divisions. The upper one contains a numerous suite of sand and gravel beds having a ferruginous character, and containing but few organic remains. The lower division consists of strata which have no other distinction than that of being crowded with very peculiar shells, zoophytes, and some bones.

The nearest point to the metropolis at which the Crag may be seen is not Walton Naze, as stated by Mr. Phillips, but Danberry hills. The nearest place on the Norwich road at which we have observed it is Blackbrook hill, near Stratford; but this is the upper deposit, and is without fossils, excepting a thin stratum of ferruginous sandstone, which bears impressions of the patella, cardium, and other shells.

"There are few localities of Crag," says Mr. Taylor, "in which its shells have remained wholly uninjured by

the tumultuous action of the waves. So far as our observation has extended, these shells seem to occur in a more comminuted state at their greatest distance from the present sea-shore: at Witnersham, Dedham, and a few other extreme points, the organic remains are broken into minute fragments; but nearer to the coast, and in the cliffs, perfect specimens may be obtained in abundance. With regard to the remains of terrestrial animals, they appear to have been drifted over the former surface, blended with its materials, and most frequently deposited along the margins of its estuaries. No instance has yet been authenticated of the occurrence of animal bones within the horizontal, undisturbed, and purely marine beds, like those near Aldburgh and Oxford; but they occur occasionally in the higher disrupted and superficial deposits, particularly along the river-banks and slopes of the valleys." One of the most characteristic sections of the Crag with fossils is, perhaps, at Tattingstow, in Suffolk, where it is considerably exposed and the stratification well developed.

These are some of the deposits belonging to this series which cannot at present be classified in any determinate order. But, as our knowledge of the Supercretaceous deposit increases, we shall probably meet

with some tests by which we shall be able to establish their relative ages. Professor Sedgwick and Mr. Murchison have, with great success, attempted to determine the age of the tertiary deposits of Lower Styria; and it is only by such rigid observation and accurate comparisons as they have exercised, that we can obtain the knowledge that is desired.

As the superposition and general characters of the regular deposits of this group are detailed in the preceding table, we shall only make a few remarks in illustration of the lower marine formation.

The London and Plastic clay formations were formerly supposed to be essentially different. But it is now generally admitted that they are but members of one series, and have no zoological separation. The London clay is a thick argillaceous deposit, containing a great number of marine fossils; the Plastic clay consists of a series of clays, sands, sandstones, and pebble beds, irregularly alternating. Of these, the sands are most extensive in England.

One of the best developed sections of the Plastic clay beds that we have seen is at Upnor, near Chatham, on the banks of the Medway. The following is the section referred to:

1. Blue London clay.
2. Brick earth, . . 15 feet.
3. Indurated marle, . . 18 inches.
4. Brown sand, . . . 18 inches.
5. Pebbles, shells, and sand, containing cytherea, turritella, and a large gibbous bivalve, but in a very decayed state, 3 feet.
6. Fine brick earth, containing two varieties of ostrea. The jaw and vertebræ of a horse, and part of the skull of an animal of the deer kind, have been found, 10 feet.
7. Clay and shells. This bed is almost composed of shells. Cytherea, turritella (three species), niga plana, ostrea tener, and murex latus, have been discovered, . . . 3 to 6 feet.
8. Ochrey bed. Composed of clay strongly coloured by oxide of iron, and containing crystals of selenite, . 2 to 4 feet.
9. Carbonaceous bed. An imperfect coal, filled with selenite, and impregnated with iron. When dry, it burns without flame or smoke, with great heat, before the blow-pipe, leaving reddish brown hard ashes. . . 4 to 12 inches.

10. A white and grey sand, . 2 feet.
11. Sand of a grey colour, till within three feet of the top, where it assumes a yellow ferruginous hue. Two species of ostrea are found. . . Depth unknown.

Till lately, there was some doubt whether fossil bones were ever found in the Plastic clay; but the above section would be sufficient to set this question at rest.

The London clay is nowhere better developed than in the Isle of Sheppey; and no deposit can contain a richer variety of organic remains. Seven hundred species of seed-vessels have been obtained from the Minster cliffs; and we have a greater number of fossil fish from the same district than can be found in any other English rock. The only remains of the higher order of animals contained in the London clay belong to the saurians and turtles.

The Cretaceous Group consists of a series of rocks known by the names of chalk, upper green sands, gault, and the lower green sands.

The Chalk is the upper portion of this group, and extensively developed in Europe, particularly in

England. It is a singular fact that the fossils of this rock occur in patches. The chalk of Sussex is remarkable for its abundance of molusca and fish; that of Hampshire for its radiaria; and Kent for its polypi and conchifera. The latter county is generally almost destitute of the remains of fish; but after an unsuccessful search, continued for several months, we found one situation in which they occur in great abundance, and from it have obtained some most beautiful and rare specimens.

The Cretaceous group may, in general terms, be described as cretaceous in its upper beds, arenaceous and argillaceous in its lower; but in the north of England, the lower deposits are almost entirely wanting.

The remains of mammalia have never been discovered in the Cretaceous group, but several reptiles have been determined, one of which, the Mososaurus Hoffmanni, was about the size of the crocodile, and appears to have been an aquatic animal.

The bones and teeth of fish have also been discovered, and some few of the crustacea. The fossil vegetables are chiefly marine: the shells are very numerous; and some few genera have been discovered which are peculiar to this series.

The Wealden Group is best developed in Sussex, and is remarkable for the beauty and singularity of its fossils. In the Hastings beds we meet with that enormous herbivorous reptile the iguanodon, discovered by Mr. Mantell, which surpassed all others in magnitude. Its teeth are as large as the incisors of the rhinoceros; and a thigh bone has been discovered which measures twenty-three inches in circumference. It is generally supposed that this animal was shorter, in proportion to its bulk, than the recent lizards, to which it is most allied; but, even with this allowance, it must have been more than fifty feet in length, and eight or nine in height.

The Oolitic Group consists of various beds of clay, sandstones, marls, and limestones, many of the latter being oolitic in their structure, that is, composed of particles which are of a roe-like form. In the south of England, this group is divided into three portions, by large deposits of clay; and geologists have generally adopted the same arrangement, and divide the oolitic group into three systems.

The highest portion of this group includes the Portland oolite and the Kimmeridge clay; in which the

bones of the ichthyosaurus, plesiosaurus, and other extinct animals, have been found.

The ichthyosaurus was a most singular reptile; it had the snout of a dolphin, the teeth of a crocodile, and the vertebræ of a fish: it had a large head, enormous eyes, a short neck, and long tail; was furnished with four broad and flat paddles, was evidently destined to live in the sea, and attained a length of from twenty to thirty feet.

The plesiosaurus bore some resemblance to the ichthyosaurus: it had four paddles, but differed from all other animals in the remarkable length of its neck. The neck of reptiles is composed of three to nine vertebræ; but in a species of plesiosaurus there are upwards of thirty. It had the head of a lizard, and the neck must have resembled the body of a serpent. This reptile was not calculated to make such a rapid progress through the waters as the ichthyosaurus, and probably lived upon fishes and molusca.

The middle system of the oolitic group includes the coral rag and the Oxford or clunch clay: the former takes its name from its being a loose rubbly limestone, containing a great quantity of madrepores. The whole system is well developed at Headington, two miles east of Oxford.

The third system comprises the cornbrash, forest marble, Bradford clay, great oolite, fullers' earth, inferior oolite, and lias.

The Stonesfield slate, which is a grey oolitic limestone, and a part of the forest marble formation, is the most singular bed of this group, and is remarkable for its organic remains, which consist of the bones of birds and amphibia, mingled with the remains of shells and vegetables: the monitor, sauri, and the ichthyosaurus, have been found; also the elytra of coleopterous insects. Specimens of the remains of the monitor have been discovered, which must have belonged to an animal forty feet long and twelve feet high; and it is in the Stonefield slate that we first meet with the bones of that gigantic creature the megalosaurus, which was probably a terrestrial animal, from thirty to forty feet in length, and seven or more in height.

The lias, which is the lowest formation in the oolite group, abounds in beautifully preserved fossils, among which is the pterodactylus, a flying reptile, with the wings of a bat and the body of a reptile. It had sharp teeth and claws, with long hooked nails; its food was, probably, insects; and we generally find them imbedded in those deposits in which its remains are found.

The Red Sandstone Group may be divided into five formations: the red or variegated marls, the muschelkalk, the red or variegated sandstone, the magnesian limestone, and the red conglomerase.

The red marl formation consists, as its name implies, of a series of marly deposits, and contains a variety of vegetable remains and sometimes the scales of fish. It may be seen between Lyme Regis and Sidmouth; but is better developed on the Continent than in our own country.

The muschelkalk is a limestone usually of a grey colour and compact texture. The term is derived from two German words, muschel, a muscle; and kalk, lime. This rock is unknown in England, but in Germany and in the south and east of France, is well developed; it contains the bones of the ichthyosaurus, plesiosaurus, and saurians, with some shells.

The magnesian limestone formation derives its name from the large proportion of magnesia in the crystalline varieties: the presence of this mineral in rocks was first discovered by Dolomieu, and on this account all those limestones which contain it are called Dolomites.

The Carboniferous Group may be divided into three series, which are severally known by the terms,

coal measures, carboniferous or mountain limestone, and old red sandstone.

The series of beds denominated the coal measures, is composed of various deposits of sandstone, shale, and coal, irregularly alternating. In some situations there are not less than thirty or forty beds of coal, which are separated from each other by beds of sandstone or shale.

Shale is a slatey clay, and occupies nearly three-fourths of the mass constituting the coal measures. Sometimes beds of clayey ironstone are found in connexion with the coal, and is called metal-stone by the miners. Next to the coal, this is the most important bed of the formation, as the greater part of the iron which is used in this country is obtained from it.

The coal measures abound in most interesting vegetable remains, and it is now pretty generally allowed that coal itself had a vegetable origin. The whole of the series has been greatly shattered and contorted, and the progress of mining operations is often impeded from this circumstance. These fractures, or faults, as they are called by the miners, although very embarrassing to those who are engaged in working this valuable mineral, evince, we think, marks of deep design, which every thoughtful mind must observe. That the

Creator of all things should, in so distant an epoch of the history of the world, have provided for the comfort of his future creatures, is in itself a circumstance of grateful remembrance; but when we view, in connexion with it, the arrangement of causes which should so dispose these strata as to bring them immediately before our attention, at the surface of the earth, we cannot fail to be convinced of a superintending design.

Beneath the coal measures we come upon the carboniferous or mountain limestone, which is chiefly remarkable for the quantity of lead ore it contains. Mr. Taylor has stated that 25,000 tons are annually extracted from it.

The Grauwacke Group may be considered as a mass of arenaceous and slatey rocks, containing limestone: it is usually of greyish blue colour, but in the south of Devon is sometimes red. It is extensively distributed over the globe, and is uncommonly productive of the metallic ores: the lead and silver mines of the Hartz are situated in it. In the south of Scotland it composes many of the mountain chains, and in Transylvania is traversed by veins of gold.

This group contains a considerable variety of fossils, belonging to both existing and extinct genera: it also

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abounds with the remains of plants apparently belonging chiefly to the Equiseta and Calamites. In Ireland they are very abundant, and according to Mr. Weaver 25,000 tons are annually raised at the Dronagh collieries, (*Proceedings of Geological Society*, p. 232;) and Professor Eaton states that they have been observed in the United States, at Worcester and Newport. (*American Journal of Science*, vol. 19.)

THE LOWEST FOSSILIFEROUS GROUP. "This group," says Mr. de la Beche, "should be considered as little more than one of convenience, in which rocks containing a few organic remains are sometimes mixed with strata of the same character as those enumerated under the head of Non-fossiliferous Rocks." (*Geological Manual*, p. 456.)

The principal rock of this series is the transition clay slate: the varieties of this rock are as numerous as its colours; but the almost endless change of appearances which the same rock will present, is easily accounted for, when we remember that the smallest alteration in the quantity or character of the constituent parts of any substance decidedly alters the appearance of the mass.

The finer varieties of slate are usually found imbedded

in rocks of a coarser texture, and some quarries of it are extensively worked in several counties. When carbonaceous matter is present, (and in the slate rocks it makes its first appearance,) the slate is more smooth, and the greater the proportion the more useful for the purpose of drawing.

THE LOWEST STRATIFIED GROUP is peculiarly distinguished by its chemical characters, produced in many instances by the volcanic action it has suffered. Some of these rocks are unstratified, and those that are stratified usually lie at a very high angle.

Gneiss and mica slate are the two principal rocks of this group; but with these, various subordinate ones are associated. They cannot be said to take any regular relative positions, but frequently pass into each other in so gradual a manner, that it is oftentimes impossible to say where one rock ceases and the other commences. Gneiss, for instance, in some parts of Iona, so much resembles granite, that a specimen can only be determined by a favorable fracture; and in another place, where it loses its quartz, it gradually passes into hornblende slate.

Mica slate, sometimes called Micaceous Schistus, usually superposes gneiss, and consists of quartz and

mica, but contains garnets in so great abundance, that they may be almost said to be an essential ingredient. The prevailing colour of this rock is grey; it is invariably stratified, and the strata are sometimes greatly contorted. It usually forms extensive tracts of mountainous country, but the acclivities of its elevation are not so bold and steep as those which are formed of gneiss: it is beautifully exposed at Bolt Head and the neighbouring headlands, on the coast of Devonshire.

Gneiss is that rock which usually superposes granite, from which it can be distinguished only by the general parallelism of its mica or hornblende, its composition being generally the same.

The word gneiss is said to have originated with the German miners; but it was Werner who limited the term to the rock of which we are speaking. It oftentimes forms mountains of considerable elevation, as at Mont Rosa, in Italy, and the middle range of the Pyrenees. Many of the western isles are composed of it, and it abounds in Sweden, Russia, Greece, and many other European countries.

Gneiss oftentimes presents the most curious appearance, from the contortion of its strata and the presence of veins. There is a singular instance of the former at Cuire, in the island of Barra, which Dr. Mac Culloch

has described in his interesting work on the Western Isles.

The composition of Gneiss differs but little from that of Granite; its prevailing component minerals are quartz, felspar, and mica, but hornblende and chlorite are sometimes present.

It is universally allowed to be a stratified rock, but all varieties do not present it in the same degree. When the texture is coarse, the strata are indistinct; and when it is traversed by granite veins, they can scarcely be distinguished; but where the texture is fine, and the minerals arranged in a parallel direction, the strata cannot be mistaken.

In this general view of the stratified rocks, we have endeavoured to dwell principally upon those facts which are most important to the investigation we are to enter upon. The study of Practical Geology from books is, under all circumstances, uninteresting, and particularly so when the author is compelled to take a loose and unconnected view of the subject. To feel the enthusiasm of a Geologist, it is necessary that knowledge should be acquired from nature. The elements of the natural sciences, which must necessarily be obtained in the study, need but a few hours' careful attention, and the inquirer will afterwards gain more

information from the inspection of a few specimens in their localities, than from the perusal of many books.

But before we pass from this subject, it is necessary to make a few remarks upon the UNSTRATIFIED ROCKS.

These rocks are extensively distributed over the globe, and are found in strata of all ages. Near Friedau, in Styria, trachytic conglomerates superpose tertiary deposits; and in the north of Ireland, immense veins, or dykes, of basalt traverse the chalk. And in our own country the traps are associated with nearly all formations.

The unstratified rocks are usually supposed to have originated from the action of subterranean fire, and hence it is we find them in veins as well as beds. Sometimes, entire mountain chains are composed of them; and, generally speaking, they occupy the highest portions of the globe. They have been divided into four classes, and a general sketch of the granitic, serpentine, and trappean rocks, may be given.

The Granitic rocks are chiefly composed of quartz, felspar, and mica; and two or more of these are necessary. Felspar is generally most abundant, but that mineral, as well as all others which enter into their com-

position, varies in its proportions, and is sometimes absent. A granite of Mont Blanc is composed of felspar, quartz, and chlorite; we observed one in Aberdeenshire, which consisted of felspar and hornblend; and another in Perthshire, formed of quartz, felspar, and actinolite. Mr. Poulett Scrope, in his work on Central France, speaks of a granite which constitutes an extensive tract in the department of Haute Loire and Ardêche, that contains so much pinite, that it is estimated to form a third part of the whole rock.

Sienite, which is a variety of granite, differs from that rock in having hornblend as a component part, instead of mica. This rock occurs in Scotland, and in the Malvern hills, but particularly in Charnwood forest.

Diallage Rock and Serpentine.

These two rocks are intimately connected together, and pass into each other. Diallage consists chiefly of diallage and felspar. Serpentine, so called from its peculiarly variegated lustre, resembling a serpent's skin, is a simple mineral substance. Its fracture is either splintery or granular, and has a bright lustry appearance when first broken. It is not extensively distributed, and in England is only found at the Lizard Point.

TRAPPEAN ROCKS.

The word trap is derived from a Swedish word signifying stair, and is given to these rocks because of their jagged appearance. They pass into each other so rapidly and frequently, that it is almost impossible to enumerate, and quite impossible in many instances to distinguish, the numerous varieties which are thus formed. But we cannot pretend to give in the following remarks, a description of the trappean rocks, our only object is to show the great variety of appearances they present, and the peculiarities of their composition.

The principal rocks of this class are claystone and clinkstone, chiefly composed of felspar; greenstone, composed of augite and hornblend; and basalt, consisting of augite and titaniferous iron; but the latter is not definitely described.

The simple trappean rocks become porphyritic by the admixture of quartz or felspar. The porphyries are known by the name of their base; thus we have claystone porphyry, clinkstone porphyry, and others.

Some trappean rocks appear to have been vesicular, like the modern lavas; but these vesicles have been since filled by mineral substances, having an almond shape; and are on this account called Amygdaloids.

Sometimes the trappean rocks take a columnar structure: the Giant's Causeway and Fingal's Cave, equally celebrated for their picturesque beauty and their singular geological appearance, are instances.

The Island of Sky, one of the Western Isles, affords a most excellent opportunity for the study of the unstratified rocks. This beautiful spot, the Isle of Mist, as it is called by the Gælic poet, is equally worthy the attention of the Geologist and the man who can in any degree feel the influence of rugged mountainous scenery. But it is chiefly upon the shores of this island that the objects of the Geologist's investigation are exposed to view. We can only mention one portion of this interesting coast. From a point called Ru-na-braddam to Loch Snizort, we have a series of cliffs, composed of columnar trap, resembling those at the celebrated cave of Staffa. "Although the columns are not so accurately formed, nor so distinctly marked, as in other places, their effect at the proper point of sight," says Dr. Mac Culloch, "is equally regular; while from the frequent occurrence of groups, recesses, and projecting masses, and from the absence of any superincumbent load, they are far superior, in lightness of appearance, as well as in elegance and variety of outline. In many cases where the columnar trap lies above the horizontal

strata, the appearance of architectural imitation is much more perfect than in any part of Staffa, the stratified rocks presenting horizontal courses of natural masonry; one of which, from a particular point of view, so exactly represents the general proportions and character of a circular temple of Grecian architecture, that the artist who should represent it truly, would be suspected of forcing nature into the forms established by art."

Those who have objected to the igneous origin of unconformable rocks, urge two reasons for their difference of opinion: that they are sometimes found imbedded in the stratified rocks, and that they sometimes pass by gradation into the stratified primitive rocks; from which it would follow, that these also had an igneous origin, which deduction would extend the reign of Pluto over too large a portion of the mineral masses. If these are the best arguments that the Neptunists can adduce, we are bold to say, they are nothing worth and scarcely deserve notice. With regard to the first objection it may be stated, that it is not strange that unconformable rocks are enclosed in stratified beds, and the fact only proves that the upper beds were formed after the overflowing of the unstratified mass. And with regard to the other objection, we may remark

that there is nothing to fear from the extension of Pluto's reign, if we are warranted by facts; for the only object of a Geologist should be to deduce fair inferences from geological phenomena.

To obtain an accurate acquaintance with the characters and superposition of rocks will occupy some time, and requires considerable attention. But all the fundamental principles of the science are comprised in the four following propositions:

1. The crust of the earth is composed of a series of rocks, some of which are stratified, and some unstratified.

2. The stratified rocks have a regular succession, but are often disturbed by the unstratified, which occur in all parts of the series.

3. Nearly all the stratified rocks, excepting a few which are found at the bottom of the series, contain organic remains.

4. Every bed which contains organic remains has some that are peculiar to it, and by them it may always be distinguished.

OUTLINE OF THEORETICAL GEOLOGY.

THE ultimate object of Geology, as before stated, is to gain some information concerning the formation of the world, the causes employed, the circumstances under which these causes acted, and the physical condition of the earth at each successive period of its existence. To gain this knowledge, we trace the superposition of rocks, the disturbances they have suffered, and the organic remains they contain. The facts which Geologists have discovered are, therefore, only the rudiments of their science, the principles to which the process of induction must be applied.

The first deduction to which we seem to be led is, that rocks were, in all probability, formed by agents resembling those that still exert their influence on the globe. If we were to take a view of the harbours on our own shores, or the rivers which are every where winding their courses between our rich and cultivated hills, we should see that, in different situations, various local and general causes were in action producing certain effects. Water is every where charged with a considerable quantity of sandy or earthy matter, which

it obtains from the degradation of land, and is constantly depositing. In this way the beds of rivers are filled, and rendered unnavigable, and the finest harbours are destroyed: innumerable instances of both will immediately recur to the mind.

In Lincolnshire, and other counties where the land is beneath the level of high water mark, unfruitful soils are constantly restored to a state of fertility by the simple process of introducing the water upon the land. The water being overcharged with argillaceous matter, deposits in two or three years, a bed, five or six feet thick, of rich and fertile soil. This is an illustration of the manner in which argillaceous strata are still forming, under the influence of common existing causes. And who is to determine the difference between this deposit after it has been subjected for a time to the evaporating influence of the sun, and those formed in an earlier period of the history of the earth? We are therefore warranted by analogy in supposing that the argillaceous strata of the globe may have been formed by deposition from oceans and rivers, and by those other causes which are now instrumental in producing analogous beds.

Many instances of the influence of running waters in depositing new strata might be given. So rapid and considerable is this process, that it is not at all un-

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common for rivers to destroy their own courses. The Oxon, or Jihon, which not long since flowed into the Caspian sea, now throws itself into the lake Aral. The Burrampooter has changed its course in that part where it formerly united with the Ganges, and joins that river ninety miles distant from the place of its former union; and the Euphrates and Tigris now take in part the same course, although, in the time of Nearchus, they occupied different channels.

Major Rennell, in an enquiry into the situation of Tomis, the place to which Ovid was banished, has entered into an interesting investigation of the former course of the Danube. The main branch of this river, he supposes to have ran by Tomis; for the ancient channel, which is of great breadth, may be traced from Chernavoda, on the Danube, to the neighbourhood of Baba, or Tomis. Along the whole line a chain of small lakes, sometimes connected by channels, have been observed, and these, it is supposed, are still supplied by the floods of the Danube.

"From what is known to have happened to certain other rivers, we may readily trace out the circumstances of the above changes: that the Danube, by creating impediments to its own course, by raising the level of the soil in that line, sought a lower level elsewhere.

"It is not to be supposed that the change was sudden and total, but slow and gradual; at first only such a portion of the waters as the contracted state of the old channel would not readily admit, ran out; but as the new one would be gradually enlarged by corrosion, so the other one would be filling up from the diminished force of its stream, which rendered it less and less able to remove the obstructions, until the whole would be drawn into the new channel. In tropical climates, such changes are sometimes the work of a single season." (*Comparative Geography of Asia*, vol. II. pp. 374. 378.)

In the same manner, siliceous deposits are still forming. It is not always easy to determine the local causes which influence the character of a deposit, yet it may be frequently seen, that in one place a river will deposit an argillaceous, and in another, a siliceous bed. At the mouth of the estuary of Saltcombe, on the Devonshire coast, to the west of Bolt head, there is a considerable accumulation of sand, called the Bar, from which the inhabitants of the neighbourhood have been for a long time removing many thousand tons every year, yet without any apparent reduction of the accumulated mass. But higher up the estuary, we find a deposition of argillaceous matter, so extensive as to prevent vessels of any considerable burthen, and such as formerly visited

it, from approaching. By a geological examination of this district, we found that the water of the estuary has its bed in an argillaceous slate, and the slate rocks are for a considerable distance exposed to its degrading effects. We are well aware of the influence of rivers on their banks, and therefore it is more than probable that the argillaceous bed which has choaked the estuary of Saltcombe, is the accumulation of detritus, formed and deposited by the river. But the whole of the coast beyond the Bolt head, as well as the rocks at the mouth of the estuary, are composed of mica, chlorite slate, and quartz; and their presence may probably account for the accumulation of sand at the bar.

In taking a general view of the causes which influence the character of a deposition, we are inclined to suppose that they are generally local; sometimes it may depend immediately upon the character of the rocks, of which the district may be composed, and at other times may result from currents. Of the latter, we have an excellent example in the Dogger Bank, which extends from north to south more than 350 miles, and is supposed to be an accumulation of debris, carried by tides and currents.

Argillaceous and siliceous beds are, therefore, still forming, and so entirely resemble those which are found in the crust of the globe, that we cannot possibly doubt

that they were formed by the same agents. Under a conviction of the truth of this statement, geologists determine upon the manner in which any bed was formed, by applying known causes wherever they are sufficient to account for the phenomena observed.

Modern and ancient calcareous beds also present such similarities of appearance, as will not leave room to doubt that they were formed by the same agents. It is not, however, so easy to draw the comparison in this instance as in those we have mentioned. There are various sources from which lime is obtained, and causes occasioning its deposition. But the calcareous deposits are so extensive in the secondary class, that none of the agents now existing, separately considered, could, in the present state of things, have produced them. We shall, however, in a subsequent part of this essay, have occasion to advert to circumstances which will tend to show that the temperature of the earth was much higher during the deposition of the antediluvian rocks, than at present: bearing this in mind, we shall probably be of opinion that the causes now in activity, were together sufficient to have formed all the calcareous rocks.

But if we were altogether unable to maintain by actual examinations our proposition in relation to the calcareous deposits, yet from analogy we should con-

clude, that, as all the rocks with which they are associated, were formed by causes resembling those which are still in action, so the calcareous beds must have originated in every age from existing agents. We may, however, find it interesting to enquire, how calcareous deposits are now formed, and to examine the theories which have been invented, to account for the older strata of the same character.

Calcareous deposits may in some instances be formed by the destruction of calcareous rocks. The action of the air is sufficient to crumble them in a great degree; but it is somewhat difficult to determine the precise causes of the destructive effects of the atmosphere. Water is certainly the principal agent; for, as the dropping of rain, after a lengthened period, wears away the hardest stones, so the action of atmospheric water tends to destroy the particles of rocks. The rocks in the higher regions are particularly exposed to atmospheric influence, its effects being considerably increased by the variation of temperature. Frost is a most powerful agent: when water penetrates into the cavities of rocks, and freezes, the expansion of the liquid rends asunder the most solid masses with inconceivable force, and their superficies are not less exposed to the crumbling effects of the same agent. Hence it is that the

rocks of colder climes, which are little exposed to the action of water, suffer such extensive degradation. There are several instances of the weathering of hard rocks in our own country: the Tors of Dartmoor, in Devonshire, which are composed of granite, and the Logan stones, supposed by some persons to be the work of the Druids, are excellent examples.

But the atmosphere has also certain chemical effects upon rocks. Atmospheric water has a considerable influence upon calcareous beds, especially when it contains carbonic acid in solution, as all persons who have been accustomed to a chalk or limestone district, are well aware; but when these rocks are exposed on the sea coast, or by the banks of a river, to the action of running water, the degradation is still greater.

By all these causes, calcareous rocks are destroyed; and by heavy rain or springs, the detritus is carried into the lakes, rivers, or seas, that may be in the neighbourhood. Part of this is, no doubt, deposited, but not so large a quantity as may at first be supposed.

When we remember how large a quantity of lime is taken up by crustaceous and testaceous animals, it will at once appear that a large proportion of that which is carried into the sea by various destroying agents, is thus employed. Shell fish, as is well known, cannot

form their coverings, without lime be present in the water; and when we consider the immense variety and number of this interesting class of animals, we shall find no difficulty in appropriating a considerable portion of that which is carried into the sea to their use; and at the same time we cannot deny the coralloides their share of the booty which they so admirably employ, and other classes of the inhabitants of the deep, who require it, though in a less quantity.

Taking these things into consideration, it is probable that but few limestones are formed in the present day by the degradation of rocks. The most considerable calcareous deposits are those which are produced by springs and by polypifers.

Most springs arise from the percolation of water through rocks. The atmospheric waters upon reaching the earth may, for instance, pass through a series of porous beds, but afterwards meeting with an impervious clay, or some other impenetrable body, take their course in the direction of the strata, and thus make their escape. Or they may form a passage for themselves at some place beneath the level of the enclosed waters.

Springs are all more or less impregnated with the substances through which they pass, and deposit the mineral matter which they hold in solution, in their

courses. But some are less pure than others, and have, consequently, obtained the name of mineral springs. Many of these are cold, and the majority are perhaps derived from the same source as those which contain a less quantity of mineral matter. Others are thermal, and are generally supposed to be of volcanic origin. Carbonate, sulphate, and muriate of lime, soda, silica, and other substances, are found in these springs.

James informs us, in his Rocky Mountains, that the thermal springs of Washita contain silex, lime, and iron; and those in the valley of Pyrmont hold magnesia, lime, iron, and soda. Sir George Mackenzie and other writers on Iceland inform us that the Geysers deposit so large a quantity of silex, that the neighbouring vegetation is incrusted with flint. But the most remarkable deposition of silex is that at St. Michael's, one of the Azores. Dr. Webster discovered a bed of reeds, similar to ethos now flourishing on the island, entirely petrified. (*Edinb. Phil. Journal*, vol. vi. p. 310.)

It is difficult to determine how the solution of silex is effected; but we have many instances of its occurrence in the vegetable kingdom, for which it would be equally difficult to account. Many of the grasses, canes, and other plants, particularly the green bamboo, contain it

in large quantities. But lime is the most common and most abundant deposit of mineral springs. At San Vignone, in Tuscany, there is a thermal spring of great heat, which deposits a large quantity of calcareous matter. One stratum, according to Mr. Lyell, is fifteen feet thick, and is used for architectural purposes. And so rapid is the deposition near the source, that a foot of solid travertino is formed yearly in the pipes that convey the water into the baths. (*Lyell's Principles of Geology*, vol. i. p. 202.)

This single example will be sufficient to prove that a considerable quantity of calcareous matter must be deposited by thermal springs, for it is not an extraordinary occurrence; nor are the cold springs entirely inactive in the deposition of lime. Upon the flat lands above the celebrated falls of Terni, according to Mr. De la Beche, (*Manual of Geology*, p. 137,) which were artificially formed, a considerable deposit of lime has taken place; and in the country around there are many examples of the deposition of travertins by springs.

Mineral springs are generally supposed to be in some manner connected with volcanic agency, though they are still attributed by some to the passage of water through destructible rocks. There are certain springs which, from their immediate connexion with volcanos,

or situation in countries which have experienced the effects of their action, may certainly be said to have some intimate relation to the same cause. Such are the Geysers of Iceland, an island equally remarkable for the abundance of its hot springs and the violence and number of its volcanos. There are other springs, of which we must speak more cautiously, as circumstances seem rather to induce the supposition that they derive their heat and minerals from other causes, as the mineral springs of Buxton and Bath.

It is a question then of some importance, we think, to determine whether all mineral springs have the same origin; and if it be discovered they do not, to acquaint ourselves with the general phenomena by which they may be determined. At present, our knowledge on this subject is very imperfect, and opinions are rather derived from prejudice than proof.

The principal arguments for the volcanic origin of mineral springs are the following:

1. That, like volcanos, they are generally distributed, and occur in all rocks, from the oldest granite to the newest tertiary.

2. That nearly all the ingredients found in mineral springs occur as sublimates in volcanos.

3. That gaseous exhalations accompany both mineral springs and the activity of volcanos.

4. That violent earthquakes, which are undoubtedly connected with the volcanic cause, influence mineral springs, even when situated at a great distance from the seat of convulsion.

5. That volcanic eruptions are frequently accompanied by the bursting out of new thermal springs, which cease with the volcanic action, and return periodically, like the eruptions themselves.

As our object is not so much to investigate the cause of the agents which are still effecting changes on the surface of the globe as their effects, we cannot enter more at large into this interesting inquiry. In estimating the influence of mineral springs in the deposition of lime, we are led to suppose that their effects are not inconsiderable, though local; but, if it should be demonstrated that they arise from the volcanic cause, the extent of their deposits would be regulated by the intensity of that all-important agent.

From a knowledge of these facts, we shall not be surprised when we observe in the solid strata of the globe, limestones connected with volcanic rocks. This is not of unfrequent occurrence, and although we cannot

assert that all limestones thus associated were produced from springs, yet there are frequently reasons for this conclusion.

If we take into consideration the greater surface temperature of the earth at a former period than at present, and the greater activity of the volcanic cause as exhibited by rocks, we shall have an additional reason for attributing to mineral springs the formation of many of our calcareous deposits. Nor need we be surprised at the presence of silex, as the springs of St. Michael afford us a proof of the same phenomena.

But coralloides are, in all probability, the most active agents, of the present day, in forming calcareous deposits. The extensive reefs which are formed by these little creatures is almost beyond imagination. But they do not, as is usually supposed, raise their work from the bottom of the sea, for several genera cannot exist at great depths; they fix themselves upon some subaqueous elevation, and erect their dwellings upon it. This will account for the great depth of water which has often been observed in the immediate vicinity of coral reefs. The supposition that considerable districts at the bottom of the sea are covered with coral rock is, therefore, erroneous.

Coral reefs are not entirely composed by the litho-

phytes. The remains of shell-fish are, as might be expected, frequently found in them, and the whole is cemented together by calcareous sand, produced by the pulverization of shells. In this way coral rocks are formed, until they rise just above the level of the sea, when they are abandoned by the insignificant artificers.

It has been observed by modern navigators, that coral rocks, in some situations, take an oval or circular form. This is supposed to arise from their fixing themselves upon the summits of sub-marine craters; and as we are acquainted with the presence of volcanic vents in all the seas where this peculiarity has been observed, it is not an improbable supposition. In the Isle of France a bed of coral ten feet thick has been observed, lying between two currents of lava. And Captain Beachy states that Ducie's Island, which is composed of coral, is of an oval form, with a lake of very considerable depth in the centre.

In closing our observations upon the causes which are now producing calcareous deposits, we shall only refer to Mr. Lyell's description of the recent beds of shell marl and limestone at Bakie Loch, Forfarshire, which is an instance of the united effects of testaceous animals and calcareous springs.

The shell marle is of a yellowish white colour, and

contains the horns of stags and bulls, as well as the shells of the helix, turbo, limnea, and other fresh-water testaceous animals. No stream enters the lake, but it is fed by those which are irregularly distributed over its bed; and in the vicinity of these springs, the deposit is purely calcareous.

The limestone is of the same colour as the marle, and consists almost entirely of carbonate of lime, which is hard and compact. Remains of a vegetable called the chara, (the chara hispida,) were found in this deposit.

The Bakie Loch is situated in a district entirely composed of sandstone; and the water of the principal spring, which rises at the bottom of the loch is, according to an analysis by professor Daubeny, "remarkably pure and exempt from mineral contents. The specific gravity exceeds that of distilled water, by less than $\frac{1}{300}$th part, and when evaporated in an exhausted receiver, it bears only $\frac{1}{2000}$th. This residuum consists chiefly of dark coloured vegetable matter, but it must also contain lime, since oxalate of ammonia renders the water turbid; the presence of carbonic acid is very evident." (*Geol. Trans. N. S.* p. 80.)

If so minute a quantity of calcareous matter be present in the water, it is quite certain that the beds referred to could not have been formed by deposition from it, unless

it formerly contained a much larger quantity than at present. Mr. Lyell, therefore, supposes the shell marle to have been formed by the testaceous animals, whose remains are found; and that they derived the lime which is necessary for them, from the springs, or the charæ. Allowing that a sufficient quantity of lime was thus produced for the animals to exist in the waters, they may have formed the shell marl; and it is evident that when a bed of the shell marl had been deposited, the carbonic acid would form a solution of that bed, and produce the limestone.

From these observations it will appear that the calcarious deposits which are now forming, arise from either the degradation of rocks, deposition from springs, or the accumulation of the remains of testaceous animals. The coral rock is certainly the most extensive formation, but it must be borne in mind that all testaceous animals assist, in some degree, in the production of coral reefs.

Having taken this general view of the causes which are still producing calcareous deposits, we may refer to some of the theories which have been invented to account for the formation of the more ancient beds. That all the agents we have mentioned contributed to

the production of the fossiliferous cretaceous rocks, there can be no doubt; and it is equally certain that they acted under circumstances which promoted their activity. The great error into which geological theorists have fallen is, that they have attributed the production of a whole series of rock to an individual cause, instead of tracing the union of agents, and determining upon the one which has been most effective. Unfortunately, we are compelled in our endeavour to simplify science, to examine causes in their individual characters, although they are combined in nature, and greatly modify each other.

It has been maintained by some persons, that the limestones were formed from the destruction of pre-existing rocks. If this had been the only cause in action, we should expect that calcareous deposits would decrease in quantity as we ascended in the scale of rocks; but instead of this being the case, the limestones seem to increase the higher we ascend. But if it should be supposed that so large a quantity of the older rocks were exposed at each successive formation as to give an increased quantity to the higher portions of the series, and that this was universal, we are still unable to account for the local characters with which

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they are often impressed, or to reconcile it with the various appearances they present.

It has also been supposed that they resulted from the exuvia of testaceous animals. To this it has been objected that all testaceous and crustaceous animals require a supply of carbonate of lime to form their coverings, which are supposed to constitute the limestone. If we endeavour to account for this necessary supply of lime from its presence in the vegetables they use as food, it is at once evident that the theory must be erroneous, for their food could not have contained more lime than similar vegetables in the present day; and we do not find that limestones are now formed by testaceous animals under the same circumstance. Nor could the medium in which they lived have contained more lime than the waters of the present day, for then it would have been gradually exhausted by the animals who were extracting from it, and limestones would necessarily be less numerous the higher we ascend in the crust of the earth.

But, independent of these arguments, there is an improbability about the supposition, particularly when we take into consideration the relative positions of the limestone deposits. Yet there can be no doubt that coralloides and shell-fish contributed in no ordinary

degree to the formation of many of our calcareous rocks; we might mention the coral rag, among others.

Another supposition is, that the limestones were produced by the passage of water containing carbonic acid through pre-existing rocks. This, in all probability, was the origin of many small local deposits, but is evidently quite insufficient to account for those immense collections of limestone rock that are spread over the whole surface of the globe. For if the lime deposited in this way could account for all limestones, then it would appear that the small quantity obtained from pre-existing rocks, by springs, could form a mass larger than that from which it was taken; but the limestones, as already stated, are more abundant in the upper than the lower parts of the earth's crust.

But, although neither of the above theories can account for the formation of all limestone rocks, yet they may all have been employed, sometimes unitedly, and at others separately.

"Lime," says Mr. De la Beche, "has been derived somewhere, and we have reason to believe from the interior of the earth, otherwise, there is a difficulty in explaining the observed phenomena. The reason why extensive tracts of carbonate of lime have been produced at one time more than another, is not quite so

apparent; but it may be observed, as a mere conjecture, that as this substance is not very unfrequent in volcanic regions, great disruptions of strata may have produced circumstances favorable to its deposition; and that without disturbances, carbonate of lime may have been thrown upwards in water, through fissures, more abundantly at one time than at another, from causes unknown to us."

All these theories are founded upon the admission of the principle for which we are arguing. Allowing that rocks in all ages have been formed by the same causes, Geologists have investigated into the nature of those which are still active, and applied them to the deposits which are found among the solid strata of the globe. To determine which of these we have referred to have been chiefly instrumental in particular instances, we must observe the general appearance the bed presents, the nature and situation of the deposit, the state of the earth during its formation, and the character of its fossils.

In order to ascertain the manner in which beds of gravel and conglomerate were formed, we have only to trace the influence of violent storms upon mountain chains, or even the effects of running water upon siliceous substances, to see that causes are still in action producing similar deposits.

The ruin and desolation of nature which accompanies a hurricane, which is one of the violent agents of destruction, is almost beyond description. It may generally be foretold, like the volcano, by a peculiar stillness of the air; but there is also a mistiness of the atmosphere, which gives the sun a dark red tinge; the sky is soon overcast, the clouds gather together with a wild appearance, the wind rises fiercely, and the waves are tumultuously tossed over each other in the most ungoverned confusion. The rain then descends in torrents, and all nature is wrapt in darkness, that is only penetrable by the vivid lightning. The animal, vegetable, and mineral, world, all suffer under its rage: rocks are broken into fragments, and scattered around; every plant and tree is uprooted, and the animals are either suffocated by the wind or buried in the ruins around them. Thus, in a few hours, the most fertile district is turned into an uninhabited wilderness. Such is the character of the hurricanes that so often afflict the West India Islands. By this, as well as more moderate means, rocks are destroyed, and when the fragments have been rounded by attrition, they are collected, and form gravel, or conglomerate beds.

That beds of gravel and other strata containing rounded pebbles, were formed by the action of water, is

quite certain. If we examine the stones which lie upon the shores of the sea, and the margin of lakes, we uniformly find them smoothed by the action of the waves; and we can have no better proof of the former existence of a water-course than the presence of rolled pebbles. We therefore conclude, when we find beds of gravel among the solid strata of the globe, that, by the force of conflicting waters, hurricanes, or other violent causes, rocks have been broken and disintegrated; that those fragments which could not resist the solvent principle of the water have been taken up by it; and that those which have been of such a chemical composition as to prevent solution, have been rolled; and that the argillaceous or other matter held in solution has been afterwards deposited upon the rolled pebbles. This process is still going on in the beds of many rivers, and we therefore think ourselves warranted in supposing that those of antecedent date had the same origin.

These observations are entirely confined to the fossiliferous stratified rocks, and the same course of argument cannot with propriety be applied to those that are destitute of fossils, for the majority present a chemical appearance and characters which are not observed in any deposits of more recent formation.

It is not surprising that in the early ages of Geology,

the minds of men were tortured with imagining the causes which could have operated in producing the several phenomena they observed; and when we remember the tenacity with which men hold their opinions, it will not appear singular that they should be unwilling to renounce their first impressions. This premature deduction from isolated facts has given rise to a variety of opinions, on every theoretical branch of our science, which differ from each other as much as if they concerned different subjects. "Yet," says De Luc, "if there be a science in which advances ought to have been made with that scrupulous caution so judiciously recommended by Bacon, it is Geology; for the history of the earth is inseparably connected with that of man."

There are three opinions which have been maintained concerning the formation of the non-fossiliferous stratified rocks: that they were deposited from fluid; that they were produced by the action of fire; and that they were created, in situ, as we now find them.

"The first formations," says D'Aubuisson, "were produced by a general cause. We can represent them to ourselves as precipitations from an universal dissolution, that is to say, from a dissolution that covered the whole terrestrial globe. While this dissolution deposited one substance, or one rock, in one place, it is

very possible that it produced no precipitate of the same species in another; either because the constituent principles of the rock were not in sufficient quantities in that part of the dissolution, or because the causes of the precipitation did not there exercise their action, or lastly, because other causes obstructed them. In this place, they deposited granite; a little further, mica slate, because the elements of mica were, perhaps, in a greater quantity in that part of the dissolution which covered the latter place."

Other writers have maintained the igneous origin of all the non-fossiliferous rocks; but it is not probable that any geologist of the present day would defend such an opinion. But professor Mitsherlich has considerably extended our knowledge of the effect which fire has had in the formation of some of the non-fossiliferous stratified rocks, as well as those which are unstratified. This celebrated chemist, when making some inquiries at Fahlun, concerning the extraction of copper, found that the scoriæ often contained some well defined crystals, and that the whole mass of the clay had a crystalline texture; and in almost every foundery that he afterwards visited, he observed crystalline combinations, which resembled minerals. By pursuing the inquiry into which his mind was thus led, he succeeded

in forming by fire, a great variety of mineral substances, among which mica and other constituents of rocks are mentioned. From these discoveries he was led to the conclusion that many of the non-fossiliferous stratified rocks were produced by fusion, which, he says, affords an easy explanation of the increase of temperature, as we proceed into the interior of the earth, as well as of hot springs, and other phenomena.

Mr. Penn and his school, suppose these rocks to have been called into existence by the almighty fiat, by an immediate simultaneous operation. He denies the interference of all secondary causes, and considers them as parts of the earth, as it came from the hand of its Creator.

That this world was created by the almighty fiat, at once, in a moment, and without any secondary causes, is, we think, a proposition that cannot be controverted; but we are unable to say that the non-fossiliferous stratified rocks are parts of that world. Of this, however, we may be quite certain, that if they are parts of the primitive earth, they have suffered great changes from the action of both aqueous and igneous causes.

We have thus endeavoured to prove, that all the fossiliferous stratified rocks were formed by causes that are still productive in the formation of strata. It

has also been stated that during the deposition of these rocks, circumstances were more favourable to extensive and rapid results than at present, chiefly on account of the greater surface temperature.

The non-fossiliferous unstratified rocks appear to have been produced by certain chemical laws, which have had a contemporaneous operation over the entire surface of the earth, and that at a time previous to the existence of animal and vegetable life.

But all the stratified beds are considerably disturbed by the unstratified rocks, which are continually found among them, both in the form of beds and veins. It may not, therefore, be improper, before we pass from this part of our subject, to dwell upon the causes which produced them.

There has been great dispute among geologists whether these rocks were formed by fire or water; but this question may now be considered as decided. Both from their vitreous appearance and their resemblance to modern lavas, it is quite certain that they had an igneous origin.

The principal difference between the development of volcanic agency during the formation of the stratified rocks, and in the present day, consists in this circumstance, that lava was formerly ejected through wide and

extensive fissures, and now makes its escape from a confined crater. This enables us to account for the immense beds we sometimes find between stratified deposits. A rent in the solid rocks, perhaps many miles in length and of considerable width, has been first effected by the volcanic cause; the heated rocks have then rushed upwards like a torrent, and flown over the surface. A new order of things has afterwards arisen, and in process of time stratified beds have been formed upon the volcanic rock.

Veins may have been formed in two ways, by ejection from below, or by intrusion from above. Let us suppose a mass of overlying rocks to be rent by volcanic force; the violent disturbance necessarily dislocates and cracks the whole mass in various places. Through some of the fissures which conduct to the surface, the intumescent mass is ejected, and flows over the superposing bed; but, immediately the opening is formed and the lava begins to flow, all those smaller fissures which are not connected with the surface, are filled, and form injected veins. The other method by which veins may have been formed, is by intrusion; for if fissures should exist on a surface over which lava flows, they must necessarily be filled by the liquid rock.

That this has happened from volcanic action in the

early ages of the world, we are quite assured, from actually tracing the veins through successive formations. And if any further proof of the prevalence of igneous causes during the deposition of strata were required, we might refer to the influence which unstratified rocks have had in upheaving them, and forming mountain chains.

Being satisfied as to the manner in which these rocks were formed, it may be useful to enquire into the distribution of the volcanic agent in the present day, the character of the rocks formed, and the cause which produces the ejection.

Volcanos have been observed to occur in three distinct relative positions. Sometimes they are isolated, or stand separate from all others; such are Etna, and the Peak of Teneriffe. Sometimes they are found in irregular groups; this is the case with many of those situated in islands; and at other times they are ranged in right lines, which is the position of the South American volcanos, and suggested to Humboldt the probability of their being ranged over an immense chasm of volcanic matter.

It is a striking fact that the greater number of active volcanos are in islands, many of which appear to have derived their origin from successive eruptions. This

accounts for the fewness of the sub-aqueous volcanos. When we consider how much greater surface is covered by water than by land, it at first appears singular that so few should be found beneath the sea. But this is easily explained: the action is not less violent beneath the water than above it; but from the violence of the volcanic cause, islands are raised.

Those volcanos which are situated on our continents are either in the immediate neighbourhood of the sea or some large salt-water lake. Some of the American volcanos seem to be exceptions to this general rule; but these are universally connected with other mountains, which have water in their vicinity; and it has therefore been supposed that there is an internal connexion between them. Jorullo, for instance, is at a considerable distance from the sea, yet it is connected with the Atlantic by Tuxtla, and with the Pacific by Colima.

It therefore appears that there is some connexion between the presence of water and the activity of the volcanic cause: what influence the fluid may have in promoting eruption, we cannot pretend to determine; but if we examine the situation of volcanic rocks in the ancient strata of the globe, we may assure ourselves that water existed in their neighbourhood also, previous to eruption.

It may also be remarked that volcanic activity in all situations presents the same phenomena, modified by local circumstances. Volcanos have been divided into three classes: those that are in a state of permanent eruption; those whose activity is moderate; and those whose eruptions are violent, but characterized by prolonged intermittences.

The volcanos of permanent activity are few in number, and are not known to produce any violent consequences. Stromboli is one of this class, and has been in a state of constant eruption, for more than two thousand years. It seldom or ever throws its lava over the crater, but incessantly ejects large masses of burning rock and cinders.

Under the class of moderate activity, we may mention the volcano of Popocateptl, in Mexico, which was found in this phase by the discoverers of that country.

But the majority of volcanos belong to the third class, and are characterised by unfrequent, but violent activity. This, according to Baron Humboldt, is always the condition of lofty cones, and arises in all probability from the violent exertion that must be required to raise the lava to the summit of the mountain; and we consequently observe that they usually eject their lava from lateral openings. During the periods which intervene

between the eruptions, they are generally in a state of perfect repose; but when they are excited to action, it is most terrible. The dreadful eruption of Tomboro, in the island of Sumbawa, is still in the recollection, and its violence may be best estimated by the fact, that its detonations were heard at a distance of nine hundred and seventy miles.

But, although there are degrees of violence, and differences in the periods of activity, yet there are certain general phenomena which precede and accompany eruption, proving that they arise from the same cause. And if we examine the lavas which are ejected by modern volcanos, and the igneous rocks which occur in stratified deposits, we shall not doubt that they have originated from the same agent.

Earthquake usually precedes volcanic eruption. What the geological effects of earthquakes are, we cannot easily determine, but, from the results that appear, it is evident that they considerably disturb and disarrange strata. This may, therefore, be one of those agents which effected such violent changes during the deposition of rocks.

Volcanic action has been attributed to a variety of causes. Superstitious feelings have attributed them to supernatural agents; and there is every reason to believe

that much of ancient fable and idolatry arose from the personification of natural phenomena, particularly those of a destructive character. But, to pass over all the classical and oriental tales, we may enumerate a few of the many hypotheses which have been maintained by philosophers.

Lucretius, in his "De Rerum Natura," maintains that volcanic eruptions are occasioned by the conversion of the compressed air, which exists in the internal cavities of the earth, into violent winds by heat; and that by some most extraordinary and untold influence, the combustible bodies existing in the mountains are inflamed. The effect of this internal air he supposes to be much increased by the passage of external winds through the crater. We must, however absurd this hypothesis, grant Lucretius the honour of correcting the Aristotlean theory, that wind was an elementary substance born in the earth; for he supposes an internal connexion between volcanos and the sea, and thus contrives to fill his subterranean apparatus.

Werner and many of his school believed that volcanos were produced by the ignition of coal and other inflammable substances; and to support this theory, Pallas attributes the eruption of the mud volcanos, near the Cimmerian Bosphorus, to the ignition of the coal measures.

Briesląk thought to improve this theory by ascribing it to the ignition of petroleum collected in subterranean caverns. To ignite his reservoirs of Petroleum, he supposes the existence of sulphuric and phosphoric acid; and, in support of his theory, adduces the presence of petroleum and the acids in lava.

Sir Humphrey Davy, following out his noble discovery, that earths and alkalies have metallic bases, deduced from it a theory of volcanic action. He supposes the whole earth to have been originally a globe of metallic alloy, endowed with such properties that by a combination with the oxygen of the atmosphere, a crust of earthy matter was formed extending, in comparison to the whole diameter, only to a small depth. The nucleus of the globe he considered to be a deuoxydised metallic mass. Now, when water penetrates through the crust of the globe, and finds its way to the metallic mass, a chemical action immediately commences. The water is decomposed by the great affinity of the metal for oxygen, hydrogen gas is liberated in large quantities, and, exerting all the force of a confined elastic body, it rends asunder all obstacles, and bursts into a flame upon meeting with the atmosphere.

There is certainly a degree of plausibility, and perhaps of philosophy, about this singular theory. Admit

the metallic nucleus and its inflammability, and it will conduct you to all that is usually required, an explanation of phenomena. But, unfortunately, this is more than we can admit; and Sir Humphrey himself was induced, a short time before his death, to renounce his ingenious assumption, and to prefer an explanation founded upon central heat.

But the theory has not been entirely renounced by the scientific world; Dr. Daubeny has afforded it all the assistance of his talents; but we believe there is little prospect of establishing it in the face of the unproved suppositions it requires.

We must first allow that the alloy of which the earth is composed, is of a metallic nature. This, Dr. Daubeny considers as very probable, but we imagine it almost impossible. Little argument can be adduced on either side; it is a mere inference, and the one party is as much at liberty to infer as the other.

But, supposing that we allow this statement as true, we are then told it is of such a nature, that by the contact of water it becomes oxydized, liberates hydrogen, and absolutely takes fire. We may now find a field for argument. The nature of the metallic nucleus must necessarily be determined by the composition of the earth's crust or of lava. Dr. Daubeny states that

silica, alumina, lime, and iron, are the chief constituents of volcanic products. The metallic nucleus, therefore, is an alloy of silicon, aluminium, calcium, and iron. But of all electro-positive substances, silicon is the most incombustible; it may be made white hot in the open air without showing any tendency to burn. But there is every reason to suppose that silicon is not a metal, but that it bears a closer analogy to carbon, a non-metallic substance; and so far from alloying with aluminium, calcium, or iron, it evinces little tendency to unite with any other body, except when it is in a nascent state, or when double affinities are exerted. A consideration of the properties of aluminium is equally fatal to the theory. Water has little effect upon it, for by long boiling, when in a state of fine powder, it sustains no visible alteration. At a red heat it begins to oxydize; but we find by experiment, that its action on water is much more feeble than that exerted by iron or zinc. Of calcium and iron we need not speak; the one is only an imaginary substance, and the properties of the other are well known.

These are the chemical objections we have to Dr. Daubeny's theory. We might adduce many of a physical character, such as the arrangement of the metallic nucleus, the impossibility of water penetrating the super-

ficial crust, and the improbability of any chemical action being developed under so great a pressure; but the remarks we have already made are, we think, fatal to the theory.

Another hypothesis attributes eruption to central heat. From a variety of experiments which have been made, it seems certain that the temperature of the earth increases downwards. This fact has been made the basis of a theory; and it is supposed that the heat, in its endeavour to escape upwards, fixes itself upon some beds which are bad conductors, or non-conductors, of caloric. Gases are generated by the fusion, the superposed rocks are upheaved, and the intumescent mass is ejected through the opening.

The reader may now apply any of these explanations of the volcanic cause to the ancient rocks. We cannot pretend to direct his choice, for it appears to us one of those questions which remain to be solved.

The most remarkable difference between the exertion of the ancient and modern volcanic agent is, that, during the action of the former, lava was ejected from fissures, but in the present day from cones.

A volcanic mountain is necessarily a considerable time forming. The results of a first eruption are the upheaving of the strata, and the accumulation of a bed

of lava. By successive eruptions, the fissure which is in the first instance formed, is in part closed, the scoriæ which are ejected accumulate round the orifice, and a cone is formed. By the ejection of lava over this mound of scoriæ, it is both strengthened and enlarged. Should the eruptions be frequent, the hillock is soon formed into a hill, or even a mountain. This may be assisted or retarded, by the structure of the country. Where obstructions are presented, they increase from the accumulation of scoriæ and lava, and thus considerable deviations in the form of the mountains will be produced; but they are usually conical, as might be expected.

The ancient volcanic rocks are the result of one eruption; and, consequently, no cone could have been formed. And if the fissures are larger than those formed by modern activity, it must entirely result from the greater violence of the volcanic cause.

This general comparison of the ancient and modern volcanic rocks proves, we think, as well as the other subjects to which we have referred, that the causes now exerting their influence on the surface of the globe were instrumental in forming the rocks which compose the crust of the earth.

An argument in favor of the progressive and successive formation of the fossiliferous rocks might also

be drawn from the number and variety of organic remains, which, like the relics of art, seem to point out the character and circumstances of the age in which they lived. There was a time when philosophers, as well as the vulgar, attributed them to the Noahan deluge, and recent attempts have been made to revive the opinion. But, how ingenious soever the effort, it must, ultimately, entirely fail, and has already failed in the estimation of those who are able to judge of its merits.

But we are compelled to acknowledge the presence of the remains of organized creatures in the strata of the globe, and we cannot rationally deny that they existed under the same circumstances as their congeners at the present moment, and that the beds in which they are deposited were formed by causes that are still in action.

If the proposition which we have endeavoured to illustrate be admitted, it will necessarily follow that their formation occupied a considerable period of time, and we shall not have much difficulty in proving that it was antecedent to the universal deluge.

If in our examination we were to take only a general view of strata as a numerous assemblage of beds, formed by nearly the same causes, and without any great revolutions, we should be compelled to admit that

their deposition must have occupied a very considerable portion of time. If we watch the progressive formation of strata in the beds of rivers, even under the most favorable circumstances, we shall find that they are slowly progressive, and considerable time must elapse before they can be of any discernible thickness. The formation, therefore, of the immense mass of strata which compose the crust of our globe, must have required no ordinary space of time.

But it will be necessary to take a more extended view of this question. We are not only to consider the crust of the earth as composed of a mass of strata, but as a series consisting of rocks of various characters, and containing various animal remains. The same state of things, as we have already seen, could not have produced all the beds which are found. Sometimes a district has been under the sea, at other times it has been dry land; sometimes it has been covered with a detritus of rocks that was produced by the most violent causes, and at other times it has been the locality of a mineral spring. In whatever situation we examine rocks, we find that various causes have contributed to their formation; and we may trace in the character of the beds the various changes which have passed over the district in which they are now found. But it is not

possible that all these alterations in the physical character of a district could be accomplished without the lapse of time.

A still farther proof of the antiquity of the fossiliferous beds may be gathered from the character of the organic remains they contain. It is not uncommon to find a series of beds containing the relics of fresh-water animals, situated between those which are filled with those that are decidedly marine. Now we know from experiment and from observation that it is as impossible for a marine animal to exist in fresh-water, as for terrestrial animals to live in the sea: then, under such circumstances, a sufficient time must be allowed to admit of the alteration of the physical causes which produced one bed, and the establishment of those which produce another; for the destruction or removal of one class of animals, and the collection of another.

To illustrate our proposition that the deposition of strata must have taken a considerable time, we will endeavour to trace the progress of beds as now forming in our lakes and rivers.

Wherever water is found, there, in all probability, deposits are going on; the extent and character of the deposit evidently depends upon the locality. The first

question that arises from this statement is, how does water obtain the substances it deposits?

The substance of all the strata which water is instrumental in forming is derived from the destruction of rocks. It is characteristic of this world, that all things are passing away: the human body is continually changing its form, and all the organized creatures beneath him are either progressing or retrograding, advancing to maturity, or falling to decay. Every thing in the animal and vegetable worlds is continually presenting itself in a new form, and what it was yesterday it is not to-day. Finite in its existence, it is tending to change.

The same remarks may be applied to the world on which we tread, it is changing its appearance as we walk over its surface. That which we are in the habit of considering so firm and stable, so marked and unchangeable, need experience the effects of but few of those destructive agents which it bears in its own bosom, and its entire surface would present a new and novel appearance. How singular soever these remarks may appear, they are easily proved; and the reader need not, whatever may be the locality in which he is situated, go far for examples. But we will enumerate

the causes which are most active in the destruction of rocks.

We have already referred to the effects of the atmosphere upon calcareous rocks. But all others are in some degree affected by this apparently insignificant cause, particularly those which have felspar as a constituent. M. Daubuisson states that in a road-way cut through granite, the rock was in six years entirely decomposed to the depth of three inches; and in Auvergne and the Eastern Pyrenees, the effect has been so great, that the traveller would rather imagine himself in a bed of gravel than in a granite country.

Water is another, and the principal, cause of the destruction of rocks. This agent approaches it in so many ways, that we can scarcely estimate its effects, except in the number and extent of its deposits.

Atmospheric water affects rocks in two ways, by beating upon and running over their surface, and by percolation through them.

The effects of atmospheric water upon the surface in destroying it, and in accumulating the scattered fragments of rock, is best seen in mountainous countries. In passing through the vallies of all mountainous districts, large heaps of detritus, brought down by the torrents, may always be observed. Sometimes these

mounds are covered, and in some degree strengthened, by vegetation; but they are, notwithstanding, loose and unsolid, and always liable to be destroyed by falling waters.

During the passage of water from the surface of the earth, through a series of beds, a considerable amount of detritus is carried off, and in some instances a large tract of country will be mechanically loosened. When an accumulation of water has once formed for itself a channel, it will necessarily carry to its egress the mineral substances it takes up in its course, and deposit them in the vallies through which it may run.

There is, also, another effect produced by the percolation of water. Let us suppose the water from above to pass through a series of porous rocks, and afterwards to be stopped by an impervious clay; the water will then take its course in the direction of the stratum, and escape wherever it finds an opening. The argillaceous stratum will, in consequence of the running water, become moist and slippery, and should the strata be situated at a high angle, the whole mass will stand in danger of being unceremoniously cast into the valley beneath.

This has actually happened at Rossberg, a mountain in Switzerland, which rises to the height of five thou-

sand one hundred and ninety-six feet. Its upper beds are composed of the debris of the Alps, of a previous geological epoch, resting upon a stratum of clay, dipping at an angle of about 45°. Through these upper beds the water percolates to the clay beneath, and passing in the direction of the stratum, discharges itself into the valley below. On the 2d of September, 1806, the clay being softened, and rendered slippery by the action of the water, these beds were slidden from their situation, and thrown into a beautiful valley beneath, destroying in its ruins the once picturesque villages of Goldau and Busingen.

These are a few of the effects produced by atmospheric causes, but it must be ever kept in mind that, although we are compelled, in our endeavour to simplify science, to examine causes in their individual character, yet they are always combined in nature, and greatly modify each other. There is, for instance, a reproduction going on, as well as a destruction of land. The large accumulations of detritus, that is, destroyed materials, are not allowed to remain at the base of mountains or cliffs where they fall, but are carried away, in many instances, by the same agents as produced them.

A considerable quantity of debris is also collected by the falling of glaciers and the melting of snows. The

mountain torrents, of which we have already spoken, are considerably augmented by the liquefaction of the snows that surround the flanks of mountains.

Glaciers are large bodies of ice formed in lofty countries, above the line of congelation, which are cast down into the valleys beneath, destroying in their passage both vegetable and animal nature. They assist in the degradation of land, by transporting all those loose substances with which they come in contact. There are, therefore, usually found at the front of glaciers heaps of rock, earth, and trees, which have been driven before them in their course. Sometimes they transport blocks of large dimensions, which could not otherwise have been forced into the valleys. When they pass over precipices, carrying before them these heaps of detritus, a large quantity of fragments is hurried into the ravines beneath, causing, as we are informed by travellers, the only deviation from the solemn silence of these wild but sublime regions.

The velocity of the glaciers is comparatively small. Mr. De la Beche has stated that a ladder left by Saussure at the upper end of a glacier, has recently been discovered in the Mer de Glasse, which is a continuation of the same glacier; it was left in 1787, and it had advanced three leagues in forty-three years. But

this rapid progress for a glacier ceased upon its arrival at the Mer de Glasse; and it has been observed that a mass of rocks brought down the mountain by the same glacier did not advance more than two hundred yards in 1830.

These mounds of debris are gradually accumulated and slowly conveyed to the valleys, where they are swept away by the impetuous streams which result from the melting of the glaciers.

All rivers, also, have some effect in altering the surface of our earth, but the degree of change depends upon their velocity. The velocity of all rivers is always greatest in their centres, yet their beds and sides are constantly exposed by friction to their destroying powers. When a current passes through a hard and compact bed, it must have some considerable velocity to disengage any quantity of the rock, though rivers ever appear to be striving so to effect their progress as to suffer the least resistance possible, by cutting down obstacles, and filling up depressions. But, notwithstanding all the efforts which they are continually making, the removal of one obstacle only produces others, by which their operations are continually changed, but not lessened.

When earthy matter has been once united with running water, it tends, by mechanical force, to undermine all the rocks against which it is thrown. When this is accomplished, a portion is precipitated into the stream, a temporary increase of water is occasioned, and in course of time, the barrier is destroyed. By a repetition of these slips, sinuosities in the course of the river are occasioned; and the force of the stream is exerted, first on one side and then on the other.

By the action of the sea on coasts, rocks also suffer great degradation. The Shetland Isles, so peculiarly exposed to the uncontroled violence of the fierce Atlantic, will afford us excellent illustrations. "The Isle of Stenness," says Dr. Hibbert, "presents a scene of unequalled desolation. In stormy winters, huge blocks of stone are overturned, or are removed from their native beds, and hurried up a slight acclivity, to a distance almost incredible. In the winter of 1802, a tabular shaped mass, eight feet two inches by seven feet, and five feet thick, was dislodged from its bed, and removed to a distance of eighty or ninety feet. I measured the recent bed from which a block had been carried away, in the winter of 1818, which was seventeen feet and a half, by seven feet; and the depth, two

feet eight inches. The removed mass had been borne to a distance of thirty feet, when it was shivered into thirteen lesser fragments."

This is but one of the many instances which might be adduced, of the violent action of the sea, upon the coast of these interesting islands. At Navir, the sea has forced a passage through rocks of hard porphyry; and at Fitful Head, so well known as the resorting place of one of Sir Walter Scott's heroes, the clay slate of which it is composed is undergoing continued degradation.

The whole of the east coast of England is suffering from the action of the sea, but no part more than the Isle of Sheppey. We have seen many yards of the cliff, which is composed of blue or London clay, plunged into the sea. About twenty years since, the church of Reculver was an hundred and fifty feet from the beach; but since that time, a part of the church-yard has been washed away. The church at Minster is said to have been in the middle of the island, fifty years ago, and is now but a short distance from the coast; and it is asserted that if the destruction continues at the same rate, the whole island will be swept into the sea in about fifty years more.

When a mass of water is accumulated by any means, and the obstacles to its progress are suddenly removed,

the consequences are tremendous. In the year 1818, masses of ice having fallen in the upper part of the Vallée de Bagne, the course of the river Dranse was stopped, and, by the accumulation of the waters, a lake was formed, which was one hundred and thirty metres mean breadth, from three thousand to four thousand metres in length, and thirty-six in height, which was a volume of water estimated at twenty-nine million cubic metres. A third part of this was mechanically let off by the inhabitants, but the remainder, impatient of such slow and careful operations, broke away; and, travelling at the rate of eleven metres in a second, carried off every thing that opposed its progress, and covered the valley with immense accumulations of gravel, clay, and sand.

Floods are other causes of the degradation of rocks; those which occurred in Aberdeenshire, on the 3d and 4th of August, 1829, afford us an excellent illustration of the power of running water, in destroying rocks. This flood extended over nearly six thousand square miles, and its destruction of property and land was almost inconceivably great. The bridge over the Dee, at Ballater, was swept away by the force of the stream, and masses of rock, three hundred pounds in weight, were driven up inclined planes, which rose six feet in eight or

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ten yards; and a large stone of eight or nine tons weight was driven one hundred yards from its former situation. To us, who are unaccustomed to such violent causes, these facts are peculiarly striking; but they would be little surprising to those who have witnessed the hurricanes and whirlwinds of tropical climes.

From these general remarks, it will be evident that the action of the atmosphere, the percolation of water, the melting of snows and glaciers, the cutting power of rivers, and other causes, are constantly tending to form detritus, and together effect a considerable destruction of land. Taken separately, they may appear of little importance; but, when we combine them, and take a just and extensive survey of all, we shall not fail to perceive that important causes are still in action, producing important changes in the surface of our globe.

These are the causes which produce much of the mineral substance that is deposited by water. If no other argument could be adduced, the comparative slowness with which they operate, would be sufficient to prove that the formation of strata must have occupied a considerable time. But as we have now supplied the waters with the substance which they are to deposit, it will not, perhaps, be inapplicable to our argument, to

inquire what is done with this very considerable quantity of detritus, which is constantly carried into them.

The quantity of matter deposited by streams must vary according to circumstances; a stream of great velocity will carry off a larger quantity of debris than one which meanders slowly along. It has been calculated, that a velocity of three inches in a second, at the bottom of a river, will tear up fine clay; a velocity of twelve inches in a second, will sweep away fine gravel; but three feet in a second, will carry off angular fragments.

But the character of the course through which a stream is passing, must also be considered in our estimate of the time required to form a deposit. It may be a rock easily destroyed by water or not, and upon this, as well as the velocity of the stream, the quantity of detritus will depend. And hence, it will perhaps be generally found, that a slow stream flowing through a bed of clay, will produce more detritus than one much more rapid, passing through a limestone.

The transport of detritus is also influenced by the inclination of the bed of the river, upon which the velocity in some degree depends. But this chiefly relates to the transport of pebbles and angular fragments. Let us suppose that a river has so undermined

its banks, as to cause a considerable portion to fall in: much of this will in a short time be carried by the river from its present situation, and the argillaceous particles will be deposited in those places where the waters are most quiet, and the transport of the angular fragments and pebbles will depend upon the velocity of the stream.

These general rules may be applied to the formation of all recent deposits, that depend upon the transport of detritus, by water. It would be easy to refer to a great variety of instances, in which these principles are exemplified; but the most striking are those very considerable beds which are so frequently formed in lakes: and at the same time, they admirably illustrate the time required to form a deposit.

It is not uncommon for rivers to flow into a lake, in which will be deposited, the greater portion of that detritus which they carry down in their course. When the lakes are large, a great length of time will be required to fill them up; but, if the lake be small, and the velocity so great as to carry a considerable quantity of detritus, it will be quickly accomplished.

This may be observed, by reference to the lakes Constance, Geneva, and the smaller ones, which are situated between them. The Rhine deposits its transported materials, in the lake Constance; the Rhone, in

the lake of Geneva; the Adda and the Lago, in Como; the Ticino, in the Maggiore; and Zurich and Lucerne, receive that which is collected by several smaller alpine rivers.

The lake Como, according to recent authorities, is nearly filled by the detritus of the Adda and Mera; the former having divided the lake into two portions. The smaller of these is so shallow, from the deposits of the two rivers, that, on the eastern side, aquatic plants are seen above the water, and the process of filling up is going on very rapidly on the western side.

The upper end of the lake of Geneva, called the Leman lake, affords us another instance of rapid deposition. The Rhone flows into this lake, and deposits the entire of its detritus; when it enters the lake, it is turbid and muddy; when it flows out, it is clear. "If we could obtain," says Mr. Lyell, "a section of the accumulation formed in the last eight centuries, we should see a great series of strata, probably from six to nine hundred feet thick and nearly two hundred miles in length."

Now, supposing the superficial crust of the earth with which we are acquainted to be composed of a series of beds but little differing from each other, and presenting no remarkable phenomena, we must allow

that their formation occupied a very considerable portion of time.

But the crust of the earth, as we have already stated, consists of a number of beds of various substances, irregularly alternating with each other. It has been proved by analogy, that these beds were formed by causes still in action, in a manner similar to those that are now being deposited in the beds of rivers and lakes, and that the formation of each stratum requires a considerable portion of time. But, if it require a length of time to form a single deposit, how much greater time will be necessary to form a series, each differing from the other in mineralogical characters? Circumstances which will produce a calcareous deposit, will not produce an argillaceous. An entire revolution of local circumstances is absolutely necessary, in order to change the character of the bed. Admitting, therefore, that the strata composing the crust of our globe were formed with a rapidity of which we have no conception, from a variety of circumstances, particularly the greater surface temperature of our earth, of which we shall presently speak, it is quite apparent that they required considerable time for their deposition.

But all these beds are crowded with organic remains, and each has those peculiar to itself. In certain beds

we find the remains of animals which cannot elsewhere be found through the whole series, but *seem* only to have existed at that particular time when these beds were forming. Certain other beds contain, some in great abundance, the remains of oviparous animals; but neither above nor below them can an individual specimen be found. And there are other strata, and these among the highest in the series, which contain the bones of mammalia, but below them they have been sought for in vain. Every step, therefore, that we take in the investigation, impresses us the more deeply with the conviction that time must have long shaken its hasty wing over this terrestrial globe, and that the earth often completed its accustomed journey round the great orb of day after its creation, before the Eternal God of all placed man upon it, as the perfection of his work, and the object of his love.

But, if we would look still further into this question, we must examine the relative position of rocks towards each other. The natural position of all sediments would, of course, be horizontal, or nearly so. But when we come to the investigation of rocks as they are, we find that they have been subjected to the most violent disturbances. Here we find a series tilted by the action of subterranean fires, and upon it horizontal undisturbed

strata. In another place we find the primitive rocks thrust through a number of those that contain organic remains, forming chains of snow-capt mountains; and upon their flanks we trace a series of calcareous beds in their undisturbed position. What more sufficient proof that time was necessary for the formation of these beds can be required or given? Geologists have been charged with presumption in their deductions, but what can be clearer than the deductions they form from such phenomena as the above. Here are a series of rocks upheaved by ancient volcanic action, and others resting upon them undisturbed; surely it requires little argument to prove that the horizontal beds could not have been formed when the others were upheaved, that an entirely new state of things must have been instituted before they could have been deposited, and, consequently, that a considerable time must have transpired between the elevation of the one series, and the formation of the other.

It is not requisite for the proof of our proposition to enumerate all the phenomena presented by rocks. Wherever we examine them, we observe the combined action of water and fire; and that the several localities have at one time been beneath, at another above, the waters. Sometimes we trace the action of subterranean

fires without any visible proof, except the disturbance the rocks have suffered; and at other times we find the fissures through which the liquified rock has been cast, as well as the bed that was poured over the surface. Above these, we may observe the horizontal strata, and, perhaps, the entire series may have been afterwards exposed to diluvian action, and portions of it swept away by the force of an inconceivably violent flood.

Connect with these circumstances the fact that all the deposits have been formed under different circumstances, and the demonstration of our proposition will be tolerably complete.

The circumstances under which a bed was formed must be determined by its mineralogical composition, and the organic remains it contains: if it consist of rounded pebbles and angular flints, we know that it must have been formed under far more violent circumstances than if it consisted of clay or sand. If the stratum contain remains of animals which are known to live in seas, we say that it is a marine deposit; if its remains are fresh water, we call the deposit lacustrine, or fresh water; and if they should be terrestrial, we must judge of its origin either from the mineralogical character of the bed, or the fossils which may be associated with it, for it is possible that terrestrial animals

may be washed into the sea, although it is far more probable that they will find their graves in the bed of an inland lake or river.

But how are we to account for the alternation of terrestrial and marine beds unless we allow that a considerable portion of time was occupied in their deposition? Let us suppose that in the beds of our rivers and lakes depositions are going on, and that the remains of fresh water animals are deposited in them; before it be possible that the entire deposition can be changed and marine animals entombed, it will be necessary that the sea should be let in upon the entire district, either by the depression of the district itself or the elevation of the present bed of the ocean. These, however, are phenomena which are continually observed by Geologists, and, consequently, the same circumstances must have interfered to produce them.

The formation of strata, therefore, must have required a considerable time, and it is equally certain that they were deposited at a period antecedent to the universal deluge.

The person who has taken the slightest notice of geological phenomena, cannot have failed to observe that immediately beneath the vegetable soil, in almost all places, there are beds of gravel, sand, or clay, with rounded pebbles. These beds are composed of

the detritus, or destroyed materials of older rocks, called by Geologists diluvium; and are, in all probability, the result of the universal deluge. No fact in Geology, therefore, is more certain than that, after all the strata which compose the crust of our globe had been formed, the entire earth was overwhelmed with an universal flood. Where the water necessary to deluge the world could be obtained by natural causes, is, perhaps, difficult to conceive; or what became of it when obtained; "but it is less extraordinary," says Mr. Greenough, "that water should have stood in some former period at a height exceeding that of our highest mountains, than that strata should have been formed without a precipitate, that gravel should have been rounded without attrition," or valleys excavated without a flood.

There have, however, been some who have rejected the Scriptures on the ground that they will believe nothing that they cannot understand. Nature, say they, is our preceptress; but how often has she failed to answer their interrogations, and when she has spoken, how often has she given the lie to their principles. But this is not the only instance in which natural phenomena have corroborated the sacred records, and left the pretended admirers of nature as much in ignorance of

causes as they were before they consulted her oracle. Such men, to be consistent with their own assertions, must have formed an enormous estimate of their mental powers, rejecting, as unworthy their belief, one-half of those beautiful truths which the investigations of philosophy have discovered, but for which it cannot account.

So great was the effect which the diluvian waters had upon rocks, that in the midland counties of England a complete suite of English specimens may be collected from the gravel. And not only have gravels been transported, but also huge blocks, which could have only been removed by an enormous rush of water. Near Hayton castle there is a spheroidal mass of granite ten feet six inches in diameter, and more than four feet high. At High Peak, in Derbyshire, there is a rolled mass twenty-one feet high and nine feet wide. In some places these transported masses are still larger, and so numerous that they may be traced to the places from which they were broken. The same facts have been observed in every other investigated portion of the world; and the current seems to have taken a direction from N.E. to S.W.

Much has been written concerning the state of the earth previous to the deluge, or, in other words, upon

the effect which the waters had in causing the present superficial appearance of the earth. Some persons have maintained that, before the deluge, the world was a plane, and that all the variations of mountain and valley which we now observe, was occasioned by the action of the waters. Such an opinion, however, is the height of absurdity, for, if the earth had no depression before the deluge, it could have had no sea, and, therefore, must have been a vast, sterile, and uninhabited, desert. Some of the largest and deepest of our valleys were formed previous to the deluge, by the elevation of strata; but, at the same time, it must be remembered, that the deluge did much to give the pleasing form of elevation and depression to our globe, by sweeping over the surface and excavating valleys.

If, therefore, the beds of gravel which cover over all the strata were formed by the diluvian waters, and also the valleys which are cut out of the strata themselves; then the whole of the fossiliferous rocks were formed previous to the universal deluge. The period which intervened between the creation of man and the deluge is, evidently, insufficient to have accomplished their deposition; they must, therefore, have been formed previous to the creation of the human species.

To complete our examination of the deduction that a

considerable time was required for the deposition of the beds composing the crust of our globe, it will be necessary to consider that our earth experienced a greater surface temperature during the deposition of the beds, and that it has gradually decreased. This is a question of great importance, for it is evident that the higher the temperature, the greater the evaporation, and the power of meteoric agents, the more violent will be the storms, and the larger the quantity of detritus; consequently, deposits will be more rapidly formed in tropical than in temperate climes. And the same cause would powerfully influence the growth and increase of vegetable and animal life; hence, we find that both the land and waters are most crowded with organized creatures in the hottest portions of our globe.

The formation of strata would, consequently, be accomplished in the early ages of the world with little difficulty, for the torrents of water which would be produced under such a state of things, would be more violent and sudden than the inhabitants of tropical districts could at the present time possibly conceive; and the quantity of detritus formed would be proportionally greater than that which is now produced.

But, in addition to this, we must remember that there is no reason to suppose that subterranean forces were

less active at this period than they have since been, but, on the contrary, more violent and frequent, as we not only find igneous rocks intermixed with the deposits, but that they have suffered the most terrible convulsions. Great changes have also been produced by altering the level of land and water, and in upheaving mountain chains.

On the other hand, it may be objected, that in proportion to the increase of temperature, there will be an increase of vegetable life. But, as degradation of land is considerably prevented by vegetation, which binds and solidifies the loosest soils, so the effects of violent rains would be much less than we may at first suppose. This we are quite willing to concede, but at the same time feel no difficulty in asserting that the degradation of land in tropical climes, in spite of the antagonist power which vegetation exerts, is much greater than that which generally occurs in colder regions.

The great vigour of vegetation in tropical climes can hardly be imagined by the inhabitants of this portion of the globe. The idea of a forest from any thing that may be seen in Europe is very insufficient to paint the luxuriant vegetation of the tropics; nor could our coal deposits have been supplied from such scanty sources. We would rather refer to the vast

forests of Brazil or Guiana, almost too thickly entwined to admit of human research, and to the luxuriant and extensive woods on the banks of the Missouri. If we can imagine the immense quantities of vegetable matter which is there produced all the year round, and year after year for ages, we may perhaps approach to the state of our northern climes when our coal beds were formed. Every thing connected with the coal deposits was tropical. Such was the climate that produced, the forests that bore, and the rivers that transported into their estuaries, the vegetables which were designed by the Creator to become, in future ages, the source of comfort and wealth to his creatures!

Nor is this a merely hypothetical case. In the tropical lakes and estuaries of the present day, the same phenomena may still be seen. The Mississippi, "after the flood season," says Mr. Lyell, when the river subsides within its channel, acts with destructive force upon the alluvial banks, softened and diluted by the recent overflow. Several acres at a time, thickly covered by wood, are precipitated into the stream," and sometimes large islands are swept away. Mr. Darby informs us that a large quantity of drift wood is brought into the Atchafalaya, an arm of the Mississippi, and being there arrested, forms a raft,

which in 1816 was ten miles in length, two hundred and twenty yards wide, and eight feet deep. And in addition to this accumulation of drift wood and other products of degradation which are united to it, forming an island, a large quantity of detritus is annually carried into the Gulf of Mexico.

Another argument in favor of greater surface temperature may be drawn from the abundance and size of organic remains. The naturalist as well as the botanist seeks the tropics to study, in all their varieties, the objects of his attention. It is not in our chilly seas that we expect to find the coral reef and the swarming testacea, it is not by the banks of our lakes and rivers we study the habits of the saurians and crocodiles; we must pass into more congenial situations, and watch the banks of the Nile, or sail over the broad surface of the Pacific. Yet beneath our feet, we have enormous accumulations of animal remains in the limestones and other rocks, which could only have been produced in an equatorial temperature.

But a still greater proof that the temperature of our planet has diminished is found in the character of the vegetable remains that are imbedded in strata. In the rocks associated with our coal beds we do not find the plants which now inhabit our shores, but

arborescent ferns and other vegetables, which require a climate at least as warm as the tropics. But these plants increase in size in proportion to the height of the temperature; and as those which are found in the coal measures are larger than any that we find in the hottest regions of the present day, we may fairly conclude that there was a higher temperature, even in these northern latitudes, during the formation of the coal measures, than can now be found on the surface of the globe.

If observation be extended to the organic remains, we shall be impressed with the same fact. In certain strata of our own country the remains of oviparous quadrupeds are found, the whole class being now confined to the higher temperatures. But the animals to whom these remains belonged were of a gigantic size, and were, perhaps, the lords of the creation. The fabled monsters of antiquity which have so often delighted and amazed our childhood, become sober truths when compared with the discoveries of geologists in this department of our science. Some of these reptiles are only found in marine deposits; some were terrestrial, and others inhabited the lakes and rivers. But they all required and enjoyed a temperature

much higher than that which is now experienced in our northern latitudes.

In one deposit we meet with the remains of a monstrous terrestrial animal, at least thirty or forty feet in length, and from seven to eight in height. In another series of beds we find the bones of the iguanodon, a creature excelling in magnitude the megalosaurus himself. The ichthyosauri, crocodiles, and turtles, are also to be found enclosed in the solid strata of the globe.

Wherever we turn we find the remains of organized creatures, not only in such abundance as to assure us that they existed under the most favorable circumstances, but of such characters as to convince us that they lived in a tropical climate. It would, therefore, appear that at the time when the solid strata of the globe were deposited, the temperature was much higher and more equable than it is now.

The superficial temperature of the earth is now considerably influenced by solar heat and the change of the seasons; but, at the same time, the temperature, as is well known, decreases as we pass from the tropics to the poles. But this has not always been the case, or, at least, the temperature has been far more equable than it is in the present day.

It may not be immediately connected with our design to inquire into the cause of this change, and it would be improper to enter at large into the question. But we may, perhaps, be permitted, without much impropriety, to refer to the theories which in the present day engage the attention of geologists, although neither are, we fear, sufficiently illustrated to enable us to decide upon the truth with certainty.

It has been supposed by some geologists that the greater surface temperature of the earth, during the deposition of strata, arose from the greater internal heat of the globe.

To establish this theory, we must first prove that the temperature increases as we descend towards the centre of the earth. Observations have, in consequence, been made in some of the deepest mines; but all the methods of determining the question which have been invented are subject to so many errors, that we can hardly estimate from the results. If we take the temperature of the air, we must admit into our calculation the heat that is generated from the lights, the blasting of rocks by gunpowder, and the breath of the miners. And on the other hand it is certain, that there must be a continual rushing of the heated air up the shafts, and the pressure of the cold air downwards.

If we form our judgment from the springs which are found in the mines, we must remember that their temperature may be greatly changed by passing through a series of rocks, many of them of a composition, perhaps, tending to increase their heat.

If the temperature of stagnant waters or the rocks themselves be taken, the observations will be open to the same errors as influence the observations upon the air.

But, notwithstanding all the errors to which the experiments that have been made are exposed, it seems to be almost certain that the temperature of the earth increases considerably as we descend. Upon this assumed fact, some geologists have endeavoured to account for volcanic eruption and thermal springs. They suppose that the caloric, in its endeavour to escape upwards, fixes itself upon some beds which are bad conductors or non-conductors, and by fusion produce so large a volume of gases, as to thrust up the superposed strata, and form a vent for the intumescent mass, or to heat so intensely the rocks, as to boil the springs which rise in their neighbourhood.

There are only two arguments that we could use, were we called upon to support this theory of the decrease of interior heat.

Whatever class of rocks we examine, the action of volcanic agents upon them is most evident. This constant activity of the volcanic agent may possibly have arisen from the great internal heat of the earth; and it is quite certain that the superficial temperature must have been influenced, if such a state of the interior existed.

But the strong argument in favor of this supposition is, that thermal springs must have been much more numerous than at present; and we may thus account for the abundance of siliceous deposits. It would also follow from the admission of the theory, that their influence would be more evident in proportion to the age of the rock, and this seems to be the result of our examinations.

Sir W. Herschel has calculated that the decreased temperature of the earth may be accounted for by the fact that its orbit has been for ages becoming less elliptical, and, consequently, the minor axis increasing. Now, if it can be supposed that the earth's orbit was very elliptic, at the time of the deposition of strata, that would probably be sufficient to account for the greater surface temperature; but such a supposition necessarily implies, that they were formed at an almost inconceivably distant period of time.

Mr. Lyell explains the difference of temperature upon another principle: he considers it to depend upon the relative proportions of land and water near or at the poles. The higher the polar land, the greater would be the cold; but in proportion to the quantity of land at or near the equator, would be the quantity of water at the poles. When, therefore, the sea abounds at the poles, the temperature of the earth will be higher than when high land is present; and the more equably will that temperature be diffused. As a proof of this, he states that arborescent ferns are found in Van Diemen's land, in 42° south latitude, which is a much higher latitude than they reach in the northern hemisphere, where the climate is not so equable. And it may be generally stated, that there is more and higher land towards the north than the south pole. Mr. Lyell's theory will therefore resolve itself into the following statement. That the superficies of the earth has been, and still is, constantly changing by the agency of rivers, currents, earthquakes, and volcanos; and that this alteration of its position, relative to the equator and poles, is amply sufficient to account for any difference of temperature that may be required to explain the existence of tropical plants and animals, under any latitude.

We have thus endeavoured to give a view of the de-

ductions which we think may be drawn from an examination of geological phenomena; and we may now, perhaps, be permitted to take a hasty glance at the formation of the world.

The earth has not existed for ever. "So far as the causes now in action go, so far as our calculations will enable us to estimate their effects, we are equally unable to perceive in the general phenomena of the planetary system either the evidence of a beginning or the prospect of an end. But neither the researches of the physical astronomer nor those of the geologist give us any ground for regarding our system, or the globe we inhabit, as of eternal duration; on the contrary, there are circumstances in the physical constitution of our own planet, which, at least, obscurely point to an origin and a formation, however remote; since it has been found that the figure of the earth is not globular, but elliptical; and that its attraction is such as requires us to admit the interior to be more dense than the exterior, and the density to increase with some degree of regularity from the surface towards the centre. And that in layers arranged elliptically round the centre, circumstances which could scarcely happen without some such successive deposition of materials as would enable pressure to be propagated with a certain degree of freedom from one

part of the mass to another, even if we should hesitate to admit a state of primitive fluidity." (*Herschel's Disc. on Study of Nat. Hist.* p. 281.)

That which is eternal in its duration must have the property of unchangeableness. But this is not characteristic of the earth; it is continually changing its form, not only in its superficies, but also in its chemical composition. That which is to-day floating through the atmosphere, may to-morrow become a component part of a solid rock; and that which constitutes, this hour, the summit of a mountain, may in the next find a place in the deposits which are forming in the bed of the sea.

The earth, then, was created at some period, and this we deduce from science, independent of revelation. At the period when it came from the hands of its Creator, neither vegetables nor animals probably existed on its surface. We may therefore consider it as a barren mass of mountains and uninhabited waters.

Whether the non-fossiliferous rocks constituted part of this primitive world, we are not able positively to determine. When we consider their general chemical appearance, it may at least be as probable that they were formed by the intervention of secondary causes, as to suppose that they originated

from the immediate hand of God. But, however this may be, it can certainly be proved, that since their creation they have been greatly disturbed and disarranged by the influence of both igneous and aqueous agents.

But, from the beginning the same causes and effects have existed. Matter was created with certain laws, which are universal; as soon, therefore, as the present state of natural things commenced, the results which we now observe, followed. Rocks were destroyed by the action of the atmosphere and water; detritus was collected, and strata formed by deposition. All the causes, indeed, which now influence the destruction and formation of rocks, were in action, and by these causes, the fossiliferous strata were formed.

These reciprocal causes and effects must have been long in existence before the construction of the crust of our planet could have been completed, although strata were, in all probability, formed much more rapidly than at present, in consequence of the higher surface temperature. But after the whole was completed, an universal deluge spread its devastating effects upon the earth, and strewed it with the relics of its violent action.

These are the facts which we are taught by, and the

opinions we form from, science, independent of the assistance of that revelation with which it has pleased the Almighty to bless us. To cast from us this volume, whenever it offers us its assistance, is the most perfect madness; but if we carefully examine its assertions, and these opinions, and compare them together, we are at least in the road to truth; and there is some probability that we shall succeed in finding it. This will be the object of the succeeding chapter.

But, although we are about to enter upon the subject, we are quite aware of the difficulties which surround our path, and the impossibility of making our chain so perfect that a link will not sometimes be found necessary to complete the otherwise imperfect reasoning. In conducting this investigation, we have carefully examined the Scriptures themselves, that we might not misinterpret them; and we have overturned no geological truth, in order to combine the two statements.

COMPARISON OF THE MOSAICAL AND MINERAL GEOLOGIES.

How valuable soever the deductions of science may be, they cannot be regarded by a truly Christian mind as of equal authority with the direct testimony of God. There is a possibility, under all circumstances, that our opinions may be false, however improbable it may appear. The premises from which we argue may be erroneous, or, if true, may be the exceptions to a general rule, and not the law itself; or if the premises be perfect, the deductions may be illegitimate, either from an imperfect view of the facts, or the want of some other fact which is necessary for the argument.

While imperfection thus necessarily attaches itself to all human speculations, the word of God is necessarily true. Nor can human intellect and veracity compare itself with the perfect knowledge, power, and purity of the Almighty.

If, therefore, we admit that the Bible is divinely inspired, we cannot with propriety either doubt the expediency of comparing scientific opinions and the testimony of God, or prefer our deductions to the explicit

statements of Scripture. But we must rather experience a pleasing satisfaction in having a common test by which to estimate the value of accumulating knowledge; for, when we examine the sacred word of God for a history of the creation of the world, we come to the Creator for information concerning his own work, and the process by which he exerted his infinite power.

It is, then, important that all our opinions be compared with the infallible statements of the word of God. We may advance by the direction of nature to the highest probabilities; but, if they are contradicted by scriptural statements, they are necessarily false. A geological truth cannot be contradicted by a divine assertion, for truth is necessarily incontrovertible. Whether, therefore, we gather our facts from nature or the sacred testimony, they are the same; and, if we are agreed in receiving the Bible as divine in its origin, the error, provided there be a contradiction, must be on the side of scientific opinion, which is only worthy universal acceptation as a positive certainty when it coincides with the divine testimony.

But, while we would ever insist upon the necessity of comparing our theories of the earth with the statements of revelation, we would as strenuously oppose the false zeal of those persons who, in order to reconcile the

two, are not slow to deny the most established facts, and to overturn with a random stroke all that patient investigation and persevering genius has discovered. If the divine assertions can only be supported by such means, they can never be established at all. It is useless, therefore, to deny what has been legitimately proved; and we pity the weakness of the mind that stoops to evasion and fear.

The history which Moses has given us of the creation of the world, and its state till the commencement of the days, is evidently a mere outline. The great object of the Divine Spirit under whose guidance he wrote, was to detail the history of man, his character, condition, and prospects. He has, notwithstanding, furnished us with a few general facts, which are rather to direct our inquiries than to suspend them. Of those particular subjects on which he has not treated, we are at perfect liberty to form our own opinions. A theory of the formation of the earth ought therefore to be only a detailed description of the Mosaical history, a finished picture from the outline sketch which the Jewish legislator has given us.

The first chapter of Genesis, which contains all that God has revealed concerning the creation, may be divided into three periods: first, there is a statement

that the heavens and earth were formed by God. There is then a description of the earth previous to the days of creation, and afterwards a somewhat detailed account of the order in which the Almighty furnished the world during the six days.

All the sacred writers insist upon the creation of the universe by God; he is the great universal cause from which all things proceeded. Philosophy has discovered that it was the work of an intelligent being; but it is revelation alone that can teach his character and attributes. "I am the Lord, that maketh all things; that stretcheth forth the heavens alone; that spreadeth abroad the earth by myself." (*Isaiah*, xliv. 24.) "Let all the inhabitants of the world stand in awe of him; for he spake, and it was done; he commanded, and it stood fast." (*Psalm* xxxiii. 8, 9.) The prophet Isaiah, when foretelling (xl. 12, 13,) the future glory of Christ's kingdom, in a most beautiful manner refers to the creative power of God, "who hath measured the waters in the hollow of his hand, and meted out heaven with the span, and comprehended the dust of the earth in a measure, and weighed the mountains in scales, and the hills in a balance! who hath directed the spirit of the Lord, or being his counsellor hath taught him?" And Moses also commences his history of the Creation

by the statement, "in the beginning God created the heavens and the earth."

This statement appears to be entirely distinct from all that follows. The object which Moses had in view seems to have been comparative; and the whole stress of the sentence rests upon the word God. The Israelites had seen idolatry in all its forms, and had frequently fallen into the practice; but it was not the idols they had seen or served, that created the heavens and the earth, but God.

We are much inclined to suppose that there is in this verse an indirect reference to the worship of the heavenly host, and there is certainly a very explicit statement that they are creatures, and not creators. The worship of the heavenly host was the earliest species of idolatry that was practised. In the book of Job, probably the oldest writing extant, and certainly composed at an early period, we find a reference to the practice. Job, in his reply to Bildad, the Shuhite, in a protestation of integrity, says, "If I beheld the sun when it shined, or the moon walking in brightness; and my heart hath been secretly enticed, or my mouth hath kissed my hand; this also were an iniquity to be punished by the judge: for I should have denied the God that is above." (*Job*, xxxi. 26, 28.)

The Israelites, therefore, to whom the book of Genesis was immediately addressed, must have felt the force of the statement that "in the beginning GOD created the heavens and the earth," whether they had joined in this particular species of idolatry, or had only been the witnesses of the practice. In what view soever we consider this statement, whether as a simple assertion that it was God, in contradiction to idols, who made the heavens, as well as the body on which we live; or whether we consider it applied to them as those who had worshipped the heavenly bodies, and the things of earth, the statement was all important and interesting.

That the worship of the planetary bodies should have been the earliest species of idolatry, is, we think, more than probable. Their great glory and utility, and the sublimity of the knowledge which was early acquired, concerning their nature and revolutions, might in a great degree induce an unholy reverence. But another reason may be given for the practice; whenever the Almighty showed himself to men, it was always in the form of fire. It is possible that he testified his approval of Abel's sacrifice by fire, as he frequently in after ages thus marked his approbation. But we know that he appeared to Moses in the burning bush; to the children of Israel in the wilderness, as a pillar of fire; and by

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the same element to the high priest in the Holy of Holies. If the early inhabitants of the world had been accustomed to this consideration, it is not surprising that they felt some reverence for that emblem by which the Eternal had shewed himself; and in support of this view we might refer to the history of the fire worshippers, and other historical inquiries.

But the sun and moon were pre-eminent objects of admiration as the greater lights; and in addition to their being apparently bodies of fire, their beneficial influence upon the earth was well known. This admiration might easily be converted into unholy reverence for and worship of all the heavenly bodies; for such is still the disposition of men towards things which they hold in high esteem and veneration.

But, whatever may have been the application of this assertion to the Israelites, there is a direct statement that God created the heavens and the earth. This was done before the six days; how long, we are not informed, and are, consequently, at liberty to attempt to determine it by the assistance of science.

The sacred historian then describes the state of the earth at the time which immediately preceded the days of creation. The passage should be thus rendered: "But the earth was invisible and unfurnished."

The Hebrew conjunction *vau* takes a variety of significations; and it is only those that are accustomed to the Hebrew language as their vernacular tongue, who can immediately determine its proper meaning. Our only method, therefore, of fixing the precise signification of this particle is to consult the early Jewish rabbins.

"This conjunction, to which the elder Michaelis assigns thirty-seven different significations, and Noldius upwards of seventy, is a particle which discharges in the Hebrew language the functions of all the conjunctions both copulative and disjunctive; its sense being determinable in each particular case, only by the relation of the context, and the practice and genius of the language." (*Penn's Comp. Estimate*, v. i. p. 166.) By all modern writers it is in the connexion to which we now refer translated AND, by all the ancient Jewish rabbins, BUT. By the Jews of Alexandria, who translated the Old Testament into Greek nearly three hundred years before Christ, it is rendered by the Greek particle ΔΕ, which signifies *but*. Josephus also, in his paraphrase of the passage, gives it the same meaning: "In the beginning God created the heaven and the earth, *but* the latter not coming into view, but being hidden in profound darkness. (*Joseph, Ant. Jews*, v. i. p. 1.) St. Jerome also understands it in the same way; and Grotius and

others of the more modern commentators coincide in the opinion. But at the time when God came forth to create man, and to furnish the earth for his reception, "the earth was invisible and unfurnished."

Mr. Penn's excellent remarks upon this passage have established this translation. "That celebrated phrase, *tohu vabohu*, on which fancy and system have so largely and unsubstantially built, is not of uncertain signification, as has most inconsiderately and unwarrantably been assumed or pretended; for we find the most ancient interpretation of it, as delivered by native translators, uniformly maintained both in the Jewish and Christian churches for above six hundred years after their time; which prescription constitutes as solid and secure an evidence of the primitive signification of the terms as the most punctilious criticism founded on reason can require or desire in any language. Those words which our version, conforming to later translators, has rendered "without form and void," are rendered by the oldest Jewish interpreters, αορατος και ακατασκευαστος, invisible or unapparent, and unfurnished or unprovided. So, also, they were interpreted by the learned Jew, Philo. And that Josephus, whom Jerome calls "a Hebrew skilled in sacred learning from his infancy," understood the first of these words to signify in-

visible, is manifest from his paraphrasing it, not coming into view. And Jerome avowedly regarded this as the established interpretation so late as the close of the fourth century, for, in his commentary on the fortieth chapter of Isaiah, he says: "In the beginning of Genesis, where it is written 'but theearth was invisible and unfurnished,' the other interpreters have translated 'but the earth was void and nothing.'"

There are two facts which we would deduce from this statement by the inspired historian: that the world was created at some indefinite period before the commencement of the six days; and that it was created at once, without the interference of any secondary causes.

That the beginning does not refer to the first day spoken of by Moses is certain, for it is not mentioned as a part of the creation in the enumeration of that day's work. But we are, on the contrary, informed that on the first day it was in existence, though unfurnished and covered with water. The term beginning, therefore, is indefinite, and it may refer to the preceding day, or to thousands of years. To guesses there would be no end, for one would be as authorized to assert the truth of his conjecture as another; and at last must leave the decision of the question to the results of an examination into the constitution of the globe.

This is the province of Geology, and from this source only can we hope to decide the question, and to determine the state of the earth during the period which intervened between its creation and the beginning of the six days.

We are pleased to find that Dr. Chalmers does not think this view of the Mosaical statement inconsistent with the manner in which it is expressed, though we cannot allow, with him, that the substance of the heavens and earth was created before the things themselves. "Does Moses ever say that, when God created the heavens and the earth he did more at the time alluded to than transform them out of previously existing materials? or does he ever say that there was not an interval of many ages betwixt the first act of creation described in the first verse of the book of Genesis, and said to have been performed in the beginning; and those more detailed operations, the account of which commences at the second verse, and which are described to us as having been performed in so many days? or, finally, does he ever make us to understand that the genealogies of man went any further than to fix the antiquity of the species, and of consequence that they left the antiquity of the globe a free subject for the speculation of philosophers?" *(Chalmers's Evid. Christ. Revela.)*

Mr. Sharon Turner, also, well known and esteemed for his valuable historical works, entirely agrees with the principal we have advocated. "The Mosaic chronology," he says, "begins with the formation of Adam, and with the six preceding days or periods, which commenced with the production of light. What interval occurred between the first creation of the material substance of our globe, and the mandate for light to descend upon it; whether months, years, or ages, is not in the slightest degree noticed. Geology may shorten or extend its duration as it may find proper; there is no restriction on this part of the subject." (*Turner's Sacred Hist.* p. 461.)

Another fact, derived from the first two verses of the book Genesis, is, that the earth was made without the intervention of any secondary causes. What definite idea can be formed of a substance that is without form and void, we are at a loss to imagine. If we examine the cosmogony of the ancients, and even of the moderns, we find they have equal difficulty with ourselves. They have, consequently, invented chaos and all its concomitant absurdities to give an idea to an otherwise inconceivable statement, but at last darken the imagination by words without meaning. Yet phi-

losophers have been highly delighted with this shape, of their own imagination,

"If shape it may be called, that shape has none
Distinguishable."

Indistinctness, according to the metaphysicians, is one of the sources of the sublime. If this be true, it is not singular that poets should have delighted to dwell upon the grandeur of chaos; and they have all been successful, as might be expected, in discovering the beauties of this fertile field of imagination. What idea can possibly be collected from the following description by Ovid?

"Before the seas and this terrestrial ball,
And heaven's high canopy, that covers all,
One was the face of nature; if a face,
Rather a rude and undigested mass:
A lifeless lump, unfashioned and unframed,
Of jarring seeds; and, justly, Chaos named."

Dryden.

Our immortal Milton, the finest poet and the worst divine, has no clearer conception of chaos than the heathen bard:

"Before their eyes in sudden view appear
The secrets of the hoary deep; a dark

Illimitable ocean! without bound,
Without dimension; where length, breadth, and height,
And time, and place, are lost; where eldest night
And chaos, ancestors of nature, hold
Eternal anarchy amidst the noise
Of endless wars, and by confusion stand:
For hot, cold, moist, and dry, four champions fierce
Strive here for mastery."

Paradise Lost, b. ii. l. 890.

It is strange that a doctrine so adverse to all scriptural statements on the subject could ever find advocates among Christians. The doctrine of chaos acknowledges a creation of uncontrolled matter. If we suppose matter to have existed without taking determinate forms, it must have been created without laws. It is not sufficient to say that some of those causes which now influence it were not created, for even then matter must have been lawless. But matter without laws is a palpable absurdity. It must, therefore, at the moment of its creation, have been invested with all those principles which it evinces at the present moment; for the destruction of one necessarily includes the other.

And, if we acknowledge the eternity of matter, we make it co-existent with the Eternal; and instead of

making all things of nothing, all things were provided for him. And we must, ultimately, with this supposition, acknowledge its existence without laws till the formation of the world. But there are few who maintain the doctrine of chaos that give themselves the trouble to examine into the meaning of the word, much less to determine the doctrine it includes.

To the misconception of the second verse in Genesis all the absurdities of Heathen chaos may be attributed. The Chaldeans believed that darkness and water had been eternal; and that Belus, dividing the two, formed the world. This doctrine is evidently derived from the Mosaical description of the state of the earth previous to the days of the creation, and does not greatly differ from common opinion in the present day. The Egyptians held that chaos and an intelligent principle were coexistent; and the Persians only differed from them in imagining two active principles; one always attempting good, the other evil.

"Epicurus," says St. Pierre, "exhausted by voluptuousness, formed his world and his atoms, with which God has nothing to do, out of his own apathy; the geometrician forms it with his compasses; the chemist compounds it of salts; the mineralogist extracts it from fire; and they who apply themselves to nothing, and

these are not few in number, suppose it, like themselves, in a state of chaos, and moving at random. Thus they fail not to interpret the sublime operations of nature by the mechanism of the arts most familiar to them."

But the doctrine of chaos is discarded by the sacred Scriptures. GOD created the heavens and the earth; or, as the rabbins understood the passage, created the substance of them as well as formed the things themselves.

We then understand Moses to assert that at a certain time, called the beginning, God created the heavens and the earth; and that they as really appeared, and were as really in existence, as they are at the present moment. And that after they had existed an undetermined time, God came forth to create man, and previous to that act, fitted the world for his habitation; but, when he commenced this work, the earth was unfurnished and invisible.

It may now be inquired how far science and the facts of geology in particular, coincide with and illustrate these deductions.

Science, as we have already shown, demonstrates that the world must have had a beginning, and that it is the work of an intelligent and powerful being. We may also, perhaps, deduce from the same source that creation must have been an instantaneous, and not a

progressive work. This will be best done by analogy, by comparing the work of creation in one instance with that in others.

Animals, though they have existed for generations almost indefinite, have had a beginning, and must have been created. How far soever we may trace generated animals back, there was a moment in which they were first called into existence; and that moment must have been after the creation of the earth.

Generated animal bodies undergo great changes in their progress from birth to maturity. Bone, for instance, when the animal is young, is soft, and somewhat flexible, but by the addition of ossifying matter, it becomes harder and harder, until it is perfect bone, capable of supporting the mature and healthy animal.

Now in which of these states are we to suppose animals to have been created? They cannot, we think, have been formed in an imperfect state. Many animals are, in the early stage of their being, unable to provide themselves with food, and incapable of supporting life; and if they were created in this state, we must allow that a considerable time must have passed before they could have been capable of increase. It is, therefore, probable that, when animals were created, they were in a

perfect and mature state, with all their functions in that condition best adapted to the objects of their being.

The same argument may be applied to the vegetable creation; and by analogy we conclude that the earth itself was created in the same manner. Progression is inconsistent with the exercise of creative power, although it may be distinctly traced to a certain limit in all created things.

Scripture and science are, therefore, agreed on this point, that the earth had a Creator, and that it was created at once, without the interference of any secondary causes.

But the earth was not, we think, created alone; the whole of those bodies constituting the solar system were probably formed at the same moment: "God created the heavens and the earth," not merely the blue etherial space, but the bodies which revolve in it. This is, evidently, the legitimate meaning of the inspired writer.

It has already been shown that a period of time intervened between the creation of the earth and the beginning of the six days. During this period the rocks which are the covering of the globe were, in all probability, formed. The primitive rocks may have

constituted the surface of the earth as it came from the hand of the Creator; but if they did, they have since suffered considerable alterations. It has been proved in the observations upon Theoretical Geology, that all the beds between the primitive rocks and the superficial gravels were formed before the deluge, and that they all resulted from causes similar to those which are now in action. It is quite incredible that they could have been deposited in that period which intervened between the creation of man and the universal deluge. It is naturally impossible, we think, that so vast a series of deposits could have been formed in the time; but, if this objection should be considered insufficient, we must allow that the whole earth was a long time beneath the waters, for the secondary beds, with but few exceptions, were formed by the sea, and contain animal remains. The beds of the secondary and tertiary classes must, therefore, have been formed before the creation of man, and during that period which intervened between the creation of the earth and the beginning of the six days.

To this it may be objected that, as these beds contain vegetable and organic remains in great abundance, light was absolutely necessary for their existence; yet the earth was, at the commencement of the

days, in darkness. This we admit, but if any person should wish to draw from this a deduction that the earth had always been in darkness, we object to the inference. If this question must be left to deduction, there is as much probability that the darkness was casual, as that it began with the earth's creation, and remained upon it till the commencement of the days.

It has been already proved that both the earth and the heavenly bodies by which it is surrounded, were in existence before the days of creation. To suppose that they existed under circumstances different from those in which they now exist, is an absurdity, and inevitably leads to the doctrine of matter without laws. If the sun and moon existed, they gave light to the earth, as they have done since the creation of man, and will ever do as long as they bear to each other the same relations.

An argument in favor of our opinion might also be drawn from the universal law of God in reference to his creatures. All that he has made is intended to accomplish some good purpose, for he hath made nothing in vain. Nor are these in reversion, but immediate. Uselessness, even for a period, cannot be an attribute of the works of the Almighty; they are not formed until required, and cannot necessarily be allowed to remain without ful-

filling his object. It is, therefore, impossible to suppose that the world was created only to revolve in dark impenetrable space.

The existence of light from the beginning might also be insisted upon from the fact that all inorganic matter seems to have been only created to support the existence, and to administer to the comfort and pleasure, of organized being. Every spot on the rich world we inhabit teems with living creatures: from the sponges which in all parts of the globe indiscriminately attach themselves to animal, vegetable, and mineral, substances, to the more perfect animals, this fact may be traced. Away from the uninviting and crowded cities, not a step can be taken which, to explore, would fill the little span of human existence. And to suppose that this world could have existed for any lengthened period without organized being, cannot for a moment be maintained by a naturalist.

Immediately after the creation of the earth, time began. Matter was endowed with certain laws; these laws immediately began to act; and the same causes and effects were as active at that moment as they are now. Matter being finite, was no sooner brought into existence than it began to change its forms. The hard and apparently indestructible rocks that bade defiance

to the whirlwind and the storm, crumbled before the gentle breeze of heaven and the soft ripples of the ebbing tide. All outward causes contributed to its degradation and ruin; and at the base of mountains the debris was collected, or silently carried away by the passing stream.

But these were not the only causes that had an influence upon rocks: the hurricane and the tempest were there, the volcano and the earthquake were there, all the fierce and terrible agents of nature were there; rocks were broken and destroyed, upheaved and distorted. From all these causes new strata were formed, sometimes by the noiseless action of the rippling stream, sometimes by the impetuous fury of the raging tempest, and at others by the sudden and violent ejection of melted rocks from beneath, through the vast fissures which the struggling gases had opened.

To that series of rocks which rests upon the primitive, the above description may be applied. They consist of the fragments, large and small, of the primitive rocks united together, and have been tilted by the volcanic action from beneath, and not unfrequently mingled with the intumescent masses they have thrown up.

But the earth was not at this time an uninhabited desert. In the transition rocks we find a considerable

variety of shells belonging to both extinct and existing genera. Some of these were fitted to live in the fathomless deep, others to float over the surface of the broad ocean. The remains of a few fish and several genera of corals are associated with them. It is also interesting to know that at this period there was dry land as well as sea, and that it was not destitute of vegetation. The impressions of plants have been found in these strata, and in some places in great abundance. Whether any terrestrial creatures existed at this time we are unable to say; none of their remains, if there were any, have been found; and we must, therefore, for the present, suppose that they did not.

Immediately above the transition rocks we find the coal deposits, and the rocks which are associated with them. During the formation of these deposits the waters were, as in the preceding period, inhabited by testaceous animals and fishes. But the beds differ from the transition in the great abundance of vegetable matter, of which coal is entirely composed. In many of the strata connected with coal, the remains of vegetables are very numerous, and of considerable size, the ferns being sometimes fifty or sixty feet in length. The entire series may be said to be remarkable for the great

abundance and size of the cryptogamic plants which are imbedded in them.

The state of the earth during the deposition of these beds was decidedly different from that which obtained during the formation of the transition rocks. The violent impetuosity of existing causes was much subdued, although there are many proofs of considerable volcanic activity.

The fossil plants which are found in the coal strata usually occur in an horizontal position, as though they had been uprooted and thrown down previous to their being imbedded. But in some instances they are found in a vertical position, proving that the deposition of the bed in which they are found was so quiet and yet so rapid as to entomb them without injury. In every instance there seems to have been an absence of all violence; and if they did not grow in the positions where we find them, they were floated along by a perfectly quiet sea.

It is now generally supposed that the vegetables which we find in this series grew upon islands scattered through the seas. This supposition is maintained upon the fact, that the class to which they belong is such as requires considerable heat and moisture; and all those species

of the present day which have the same character and approach them in size, are similarly situated.

It is a singular fact that the vegetables which are found in a fossil state are furnished with organs of respiration, peculiarly adapted for imbibing the nutritious principles of the atmosphere. The greater number of fossil plants were succulent, and it is well known that the recent plants of the same character depend more upon the atmosphere for their existence than the soil in which they grow. This class of plants was therefore peculiarly adapted to a world rapidly progressing towards a state fitted for the existence of more perfect animals.

We may consider the earth at this period as consisting of land and water; for land was not only requisite for the growth of the vegetables whose remains we find, but there is evidence, from the extent of the mechanical rocks which abound in this series, that a considerable surface must have been above the waters.

Above the coal beds we observe a large system of mechanical rocks, called the red sandstone series. It is among these the remains of reptiles are first found, as well as other animals which have not been yet discovered in the lower strata.

It may be asked whether, upon the discovery of new genera, it may be supposed that they did not exist

previous to the time when the deposit in which they are found was formed. Some Geologists have maintained the successive creation of animals, because they find certain beds to contain fossils which are not discovered in others. This, however, is a mere supposition, and does not by any means result from discovered facts, though it may be supported by strong probabilities; but if we look at modern formations and the laws of nature, which have ever been what they are, we may perhaps discover other arguments. Let us suppose the causes which are now effecting a deposition of clay to be destroyed, and a siliceous sand to be thrown down; a great portion of testaceous animals now living in such a place would in all probability be destroyed. Every animal is suited to particular circumstances; change the condition in which it lives, and you will probably destroy the animal. This is a subject which requires extensive observation; but, although it cannot be demonstrated by the results of examination that this is the cause which produced organic remains, it has so much probability on its side, as to lead those who maintain successive creations, to investigate with more care recent strata and their fossils.

A variety of causes may have prevented the remains of an animal from being imbedded in a series of rocks.

It is quite possible that certain genera of animals may have lived during the entire period occupied by the formation of the transition rocks, and coal series, and yet not have been embedded in either. We may suppose that there are many testaceous animals that have existed in our own seas for centuries, and yet none of their remains have been imbedded in the strata that are there forming. This may result from local or general causes, the habits of the animals, or the localities they inhabit; and it is not impossible that we may overlook in many instances, the remains which are in certain beds, or they may be so sparingly distributed that our researches have not been sufficiently extensive to discover them, and that future investigators will find them in places which we now imagine to be destitute.

It is therefore hazardous to say that the reptiles which are first found in the red sandstone group did not exist previous to the time in which it was formed, although there is a decided change in the character of the organic remains.

Upon the red sandstone series there lies an immense group called the Oolites. Here we meet with a variety of animals which are perfectly new; several new genera of reptiles, testacea, zoophytes, and plants. It appears as if the waters had been more fully inhabited; the violent

actions which prevailed in the early ages of the world seem to have subsided in a great measure, and to have given place to more tranquil causes.

The last and highest series of the secondary rocks are the wealden and cretaceous groups. During the formation of these, the earth was fully inhabited; for they are crowded with the remains of animals chiefly inhabiting the ocean or estuaries. The earth at this time probably presented an appearance not very different in general characters from that which we now observe; sometimes we meet with tilted beds, and here and there with volcanic rocks; but those violent agents which in the earlier ages of the world had acted so destructively upon the world, had almost entirely passed away.

The tertiary beds, or the largest part of them, were probably formed at the same time. But to fix upon a particular stratum in the present state of our knowledge, and say, all below this were formed before the days, all above it, after, is a species of knowledge which we do not pretend to claim; but it is possible that many of the beds now associated with the tertiary deposits, may hereafter be proved to belong to the diluvian age.

It is evident then, both from Genesis and Geology, that after the creation of the earth and before the days, all or nearly all the fossiliferous rocks which compose

the crust of our globe, were formed. The character and appearance of the earth as it first came from the hand of its Creator, science will ever be unable to determine; but Geology beautifully illustrates the successive history of that extended period which intervened between the creation and its complete adaptation, as the residence of man.

That the same process is still going on in some of the planets of the solar system, is not an improbable supposition: the nearer the planet may be situated to the sun, the greater, we have thought, is it to a perfect state. Mercury is consequently in the most perfect condition; but, at the same time, only in such a state as most adapted to its present inhabitants. But Jupiter appears from observation to be almost entirely covered by water; and of the violence of its action when attracted by the united influence of its four moons in conjunction, imagination is too feeble to paint. But, whatever degree of truth there may be in this supposition, it is certain that the earth has arrived at its present condition by slow and progressive steps.

Having taken this general view of the state of the earth during that period which intervened between the creation of the world and the commencement of the days, the state of the earth at the latter period, and

the successive creations which followed, may be briefly noticed.

At the commencement of the days, the "earth was invisible, and unfurnished, and darkness was upon the face of the deep." There is here an evident distinction between the earth and the deep; they were both invisible, and the former was unfurnished. By this statement we may either understand that darkness was upon both, and that all which existed upon the land had been destroyed; or that the earth was covered with water. The latter is probably the meaning; for we find that, on the third day, God gathered the waters together into one place, and caused the dry land to appear.

The cause of this universal deluge and darkness, is not stated by Moses; but, according to the view which has been taken of the state of the earth preceding this period, it must have suffered a most important revolution. Land and water had existed during the deposition of rocks, and, in order to the accomplishment of the universal deluge, a sinking or elevation of strata seems to be necessary, or the interference of that miraculous Power which in after ages again encompassed the earth with floods; and the same Power which brought the waters over the globe, covered it with darkness,

which was, in all probability, transient; as we know that the sun and planetary bodies which act so important a part in conveying light to the world, were certainly created.

Much has been written concerning the word, יום, translated in this place, day. This word has various acceptations in Scripture, which may be mentioned.

1. Sometimes it signifies four and twenty hours; a single revolution of the earth on its axis. This is the sense in which it is used by Ezekiel: "Thou shalt bear the iniquity of the House of Judah forty days; I have appointed thee each day for a year." (*Ezekiel*, iv. 6.)

2. When it is used in the plural number it often signifies a year. It is thus used in Leviticus, (xxv. 29,) "If a man sell a dwelling-house in a walled city, then he may redeem it within a whole year after it is sold."

3. Sometimes it denotes an undefined period of time; it is thus used by the prophet Joel, (i. 15,) "Alas for the day, for the day of the Lord is at hand."

As used by Moses, in describing the Second Creation, the word evidently, we think, refers to a single revolution of the earth round its axis. If any proof of this were wanting, the use of the phrase "the morning and the evening," would decide the question.

The earth being in darkness at the commencement of

the days, God first calls or recalls the light; for there is nothing in the Mosaical statement that precludes the idea that light in the same form as it was now exhibited had existed before; but, on the other hand, every thing to strengthen the opinion.

On the second day, God created the firmament, and divided the waters, which were under the firmament, from those which were above.

On the third day the waters under the heavens, which had hitherto covered the whole earth, were gathered together into one place, and the dry land appeared. On the same day the earth was decked with its living green, and it brought forth the herb and the tree, each yielding fruit after its kind.

In order to the gathering of the waters together, some great convulsion must have transpired. On this subject we derive some information from another part of the word of God: "O Lord, my God!" says the Hebrew poet, "thou art clothed with honour and majesty; who laidest the foundations of the earth that it should not be removed for ever. Thou coveredst it with the deep as with a garment; the waters stood above the mountains. At thy rebuke they fled; at the voice of thy thunders they hasted away; they went over the mountains, they went down by the valleys unto the place which thou didst found for them."

In this beautiful passage we obtain a clearer view of the operations of the MOST HIGH in gathering the waters together. Valleys were formed, and these were probably the places which were found for them. We are, therefore, led to suppose that there was a sudden upheaving of a considerable portion of the solid crust of the earth.

Let us suppose for a moment that some of those immense mountain chains were elevated, or the whole continents of which they form a part. The mighty waters which so calmly flowed over the surface would be thrown into an inconceivable agitation, and roll their disturbed waves from shore to shore, until they had found that bound which they should not pass; and of such a convulsion there are abundant proofs in the state of the earth's crust.

What the extent of the effects produced by such a convulsion would be, it is almost impossible to conceive. But if the deluge strewed our world, from pole to pole, with the relics of its destructive agency, how large must have been the accumulation of detritus, which must have been produced by the actual upheaving of the continents? To this cause we assign many of those tertiary deposits which have hitherto been supposed to have existed before the days of creation. And if this be their origin, it is not surprising that they

should differ so considerably in their mineralogical characters.

On the fourth day God set apart the heavenly bodies for a distinct and separate purpose. "If any one," says Rosenmuller, "who is conversant with the genius of the Hebrew, and free from any previous bias of his judgment, will read the words of this article (that is, the history of the fourth day's work,) in their natural connexion, he will immediately perceive that they import the direction or determination of the heavenly bodies to certain uses which they were to render to the earth. The words are not to be separated from the rest, or to be rendered, Let there be lights, that is, let lights be made; but rather, Let lights be; that is, serve, in the expanse of heaven, for distinguishing between day and night; and let them be, or serve, for signs and for seasons. For we are to observe that the verb, הִיה, *to be*, in construction with the prefix, ל, *for*, is generally employed to express the direction or determination of a thing to an end, and not the production of a thing, as in *Num.* x. 31; *Zech.* viii. 19; and in many other places."

In accordance with this criticism, Mr. Penn translates the passage in the following manner: "And God said, let the lights in the firmament of heaven for dividing the day and the night be for signs and for

seasons, and for days and for years; and let them be for lights in the firmament of heaven to give light upon the earth; and it was so.

"And God made the two great lights; namely, the greater light to rule the day, and the lesser light to rule the night, together with the stars. And God disposed them in the firmament of heaven to give light upon the earth, and to rule the day and the night."

If this translation be admitted, we have here the existence of the heavenly bodies previous to this time directly implied; which fully corresponds with the view we have taken of their creation in the beginning. If it had been asserted that the heavenly bodies were at this time called into existence, it would have contradicted the statement in the first verse, but they were only set apart for a certain end, which was to rule the day and the night. They, therefore, existed before, and probably for many ages, and may have performed the same office previous to that catastrophe which covered the earth with darkness, and rendered it necessary for the Eternal to come forth and re-furnish and re-enlighten that world on which he intended to place his creature, Man.

The earth being thus prepared as the habitation of organized creatures, God creates, on the fifth day, all that moveth in the waters and in the air. On the sixth day

He completes his work by the creation of all living creatures that inhabit the earth, "cattle, and creeping things, and beasts of the earth." Then "God created man in his own image; in the image of God created he him."

We have thus hastily reviewed the work of the six successive days of creation, in order to show the perfect concord of this history with the view we have taken of the former verses. "Moses," says Dr. Buckland, who is an authority of the highest class, "does not deny the existence of another system of things prior to the preparation of this globe for the reception of the human race, to which he confines the details of his history; and there is nothing in the proposition inconsistent with the Mosaical declaration of the creation." But it is not sufficient to say that Moses does not contradict the supposition, for if the view taken of his history be correct, he supports and establishes the opinion.

But, whatever may be the fate of human opinions, one principle can never be disproved, that, God being the author of both the Bible and the world, the testimony of both, when accurately read, must correspond. How disdainfully soever, the divine testimony may be treated by some who are ardently engaged in the investigation of nature, all theories that oppose its statements have error as their basis, and must fall to decay.

Viewing Geology in connexion with the Mosaical history, it is the noblest science to which the reason of man can be applied. Too long has imagination wielded her sceptre over the mind of the philosopher; she has infused her baneful influence into every opinion, retarded every investigation, and dashed from every lip the cup of knowledge. Imagination is an attribute inconsistent with the investigation of nature; and the province of the philosopher is to delineate her as she is, and not in the tawdry robes and false tints with which his imagination has dressed her. In some sciences this ruling power is of less importance than in others. The astronomer, when, by the aid of his glasses, he brings the bright orb of night to the end of his telescope, may speculate upon the composition of its mountains, the brightness of its flora, or the character of its inhabitants; but his science is unaffected by his wildest imaginings. And when he comes to the admeasurement of her surface, or to calculate the periods of her eclipses, all the tales of mythologists may ramble through his mind, but will be unable to convince him that she is any thing else than a dense body, or that her surface will be darkened one moment before she is in conjunction with the earth and the sun. But in Geology the matter is far different: every fact gives an opportunity

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for a new hypothesis, and imagination may soon run wild in a scene of such novelty and grandeur.

In investigating the ancient history of the globe, the mind should be separated at once from all prejudices, and the reason should guard it from the influence of imagination. It is a subject which, pursued by an enlightened mind, fixes the attention and delights the reason. If the antiquary can feel an interest in explaining the almost-obliterated traces of art and civilization, still greater will be the delight of removing the obscurity which hangs over the history of our globe; and by deductions from a series of observations, to connect the broken fragments which are preserved in the word of truth, to direct our investigations, and develope its revolutions. Genius may here find its resource, and may expend all its powers with increasing delight. At present, we have only an indistinct view of the history of the world we inhabit; but when its various revolutions shall be determined, and the character of its past inhabitants explained, it will present the finest display of Almighty power and the capacity of human intellect, that literature ever produced, or science has ever afforded.

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